EDISON ELECTRIC CO.

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1735

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Copyright, 1909, by Munn & Co.

Published weekly by Munn & Co. at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXVII., No. 1735.

NEW YORK. APRIL 3, 1909.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE ROWELL-POTTER SYSTEM OF RAILWAY SIGNALING.

By Frank C. Perkins.

One of the most interesting of modern automatic block signal systems arranged with safety stop for the control of railway trains has been placed in operation on the Chicago, Burlington & Quincy Railroad between Big Rock, Ill., and Sugar Grove. In the accompanying illustration, Fig. 1, may be seen a signal indicator of the Rowell-Potter system on this line, showing that the main line is occupied, but also indicating that the switch is set for a clear passing track. The illustration, Fig. 2, shows the tread bar for winding the power machine by means of the wheels of the passing train. Fig. 3 shows the mechanism of the power machine for operating the semaphore blades, and the track instruments for applying the brakes inclosed in a metallic box which is installed at the base of the signal pole indicated in Fig. 1. Fig. 4 shows the track instrument for applying the brakes when the stop signal is disregarded or if the signal is out of order. Lastly, Fig. 5 shows the relay equipment for controlling the track circuit. With this automatic block signal system the standard semaphore signals of the railway are utilized (with the usual pole construction) and automatically controlled by the regulation track circuits, but operated by a novel power equipment.

FIG. 1.—SIGNAL INDICATOR, SHOWING THAT THE MAIN LINE AT MEETING IS OCCUPIED AND THAT THE SWITCH IS SET FOR PASSING THE CLEAR TRACK.

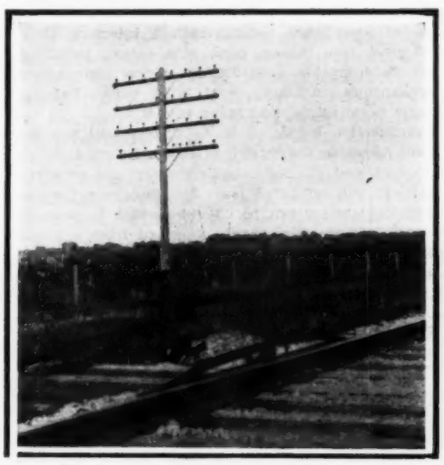


FIG. 4.—TRACK INSTRUMENT FOR APPLYING BRAKES WHEN STOP SIGNAL IS DISREGARDED OR IF SIGNAL IS OUT OF ORDER.

FIG. 5.—RELAY FOR CONTROLLING THE TRACK CIRCUIT INCLOSED IN ITS BOX.

For moving the signals and the train safety-stop devices, the power is stored in a series of a dozen coiled springs, the passing trains winding these springs up and supplying the power. One end of the spring is fastened to the inside of the cylinder, while the other end is attached to a horizontal shaft lying on the axis of the cylinder.

This case is rotated by a ratchet being worked by a vertical rod connected with a long power lever passing to the track. The power bar is operated by a treadle arrangement, which is moved by the wheels of the passing trains. Seven crank arms are keyed to the shaft, which is in turn connected to the end of the power box. The tread bar projects slightly above the top of the rail, and is depressed by each passing wheel and returned to the normal position by the counterweight effect of the long arm of the power lever, together with the assistance of a heavy coil spring under one of the crank arms. A governor is provided, which disengages the push rod from the ratchet, in order to prevent breakage when the springs are wound to their limit.

Electro-magnets control the track circuit, which unlocks the spring shaft. Power is thus delivered for the movement of these devices. The cost of power has been reduced to a minimum on this system of automatic stop signal, as batteries are required only for controlling the circuits, while the entire power for winding the machines is provided by the passing train as the wheels come in contact with the treadles above referred to.

It is stated that by means of the interlocking relays placed in the middle of each block it is impossible for two trains moving in opopsite directions and approaching the two ends of a block at the same time both to receive a signal and allow entrance to the block together.

Track instruments are provided, moving in unison with the signal for automatic train control. The arrangement is such that if an engineer fails to see a

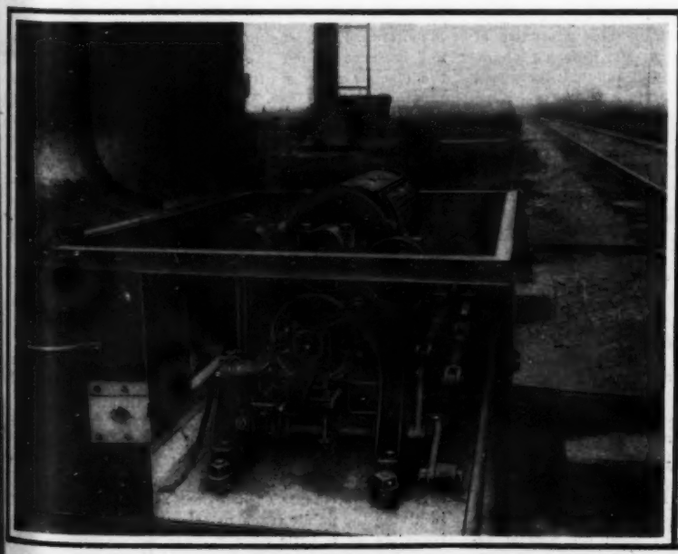


FIG. 3.—POWER MACHINE FOR OPERATING SEMAPHORE BLOCKS AND TRACK INSTRUMENTS FOR APPLYING BRAKES.

FIG. 2.—TREAD BAR FOR WINDING THE POWER MACHINE BY ACTION OF THE WHEELS OF THE PASSING TRAIN.

THE ROWELL-POTTER SYSTEM OF RAILWAY SIGNALING.

stop signal against him or ignores it, his brakes are automatically applied by contact with the brake-setting device on the engine, the track instrument being in the up position, the latter consisting of a pair of levers about four feet in length placed outside and parallel with the track rail and having sloping ends.

For each signal duplex track instruments are placed about 150 feet apart and rigidly connected with the pipe line. Should one signal be clogged, the second will stop the train. The first instrument will set the brakes if the engine is not stopped short of it with the signal of danger for an approaching train.

EDISON'S INVENTIONS.—I.

THEIR COMMERCIAL VALUE TO THE WORLD.

BY FRANK L. DYER AND T. COMMERFORD MARTIN.

IF the world were to take an account of stock, so to speak, and proceed in orderly fashion to marshal its tangible assets in relation to dollars and cents, the natural resources of our globe, from center to circumference, would head the list. Next would come inventors, whose value to the world as an asset could be readily estimated from an increase of its wealth resulting from the actual transformations of these resources into items of convenience and comfort through the exercise of their inventive ingenuity.

Inventors of practical devices may be broadly divided into two classes: first, those who may be said to have made two blades of grass grow where only one grew before, and, second, great inventors, who have made grass grow plentifully on hitherto unproductive ground. The vast majority of practical inventors belong to and remain in the first of these divisions, but there have been, and probably always will be, a less number who, by reason of their greater achievements, are entitled to be included in both classes. Of these latter, Thomas Alva Edison is one, but in the pages of history he stands conspicuously pre-eminent—a commanding, towering figure, even among giants.

The activities of Mr. Edison have been of such great range, and his conquests in the domains of practical arts so extensive and varied, that it is somewhat difficult to estimate with any satisfactory degree of accuracy the money value of his inventions to the world of to-day, even after making due allowance for the work of other great inventors and the propulsive effect of large amounts of capital thrown into the great enterprises which took root through the productions of his genius and indefatigable energies. This difficulty will be apparent, for instance, when we consider his telegraph and telephone inventions. These were absorbed in enterprises already existing, and were the means of effecting their rapid and enormous growth and expansion, particularly the telephone industry. Again, in considering the fact that Mr. Edison was the first in the field to design and perfect a practical operative electric railway, the main features of which are used in all electric roads of to-day, we are confronted with a problem as to what proportion of their colossal investment and earnings should be ascribed to Mr. Edison, who not only blazed the way, but by his foresight laid the foundation for this now indispensable convenience, that has done more than any other one thing toward the opening and settlement of our country.

Our difficulties are multiplied when we pause for a moment to think of Mr. Edison's vast influence on collateral branches of business. In the public mind he is credited with the invention of the incandescent electric light, the phonograph, and other widely known devices; but how few realize his actual influence on other trades that are not generally thought of in connection with these things. For instance, let us see what a prominent engine builder, Mr. Gardiner C. Sims, says: "Watt, Corliss, and Porter brought forward steam engines to a high state of proficiency, yet it remained for Mr. Edison to force better proportions, workmanship, designs, use of metals, regulation, the solving of the complex problems of high speed and endurance, and the successful development of the shaft governor. Mr. Edison is pre-eminent in the realm of engineering."

The phenomenal growth of the copper business was due to a rapid and ever-increasing demand, owing to the exploitation of the telephone, electric light, electric motor, and electric railway industries. Without these there might never have been the romance of "Coppers" and the rise and fall of countless fortunes. And although we cannot estimate in definite figures the extent of Mr. Edison's influence in the enormous increase of copper production, it is to be remembered that his basic inventions constitute a most important factor in the demand for the metal. Besides, we must also give him the credit for having recognized the necessity for a pure quality of copper for electric conductors, and for his persistence in having compelled the manufacturers of that period to introduce new and additional methods of refinement so as to bring about that result, which is now a *sine qua non*.

Still considering his influence on other staples and collateral trades, let us enumerate briefly and in a general manner some of the more important and additional ones that have been not merely stimulated, but in many cases the business and sales have been directly and enormously increased and new arts established through the inventions of this one man, namely, iron, steel, brass, zinc, nickel, platinum ($5 per ounce in 1878, now $26 an ounce), rubber, oils, wax, bitumen, chemical compounds, belting, boilers, injectors, structural steel, iron tubing, glass, silk, cotton, porcelain, wood, slate, marble, electrical measuring instruments, miscellaneous machinery, coal, wire, paper, building materials, sapphires, and many others.

The question before us is, to what extent has Mr. Edison added to the wealth of North America by his inventions, and his indomitable energy and perseverance? It will be noted from the foregoing that no categorical answer can be offered to such a question, but sufficient material can be gathered from a statistical review of the commercial arts directly affected to afford an approximate idea of the vast increase in national wealth that has come into being through the practical application of his ideas.

First of all, as to inventions capable of fairly definite estimate, let us mention the incandescent electric light and systems of distribution of electric light, heat, and power, which may justly be considered as the crowning inventions of Mr. Edison's life. Until October 21st, 1879, there was nothing in existence resembling our modern incandescent lamp. On that date, as we have seen in a previous chapter, Mr. Edison's labors culminated in his invention of a practical incandescent electric lamp embodying absolutely all the essentials of the lamp of to-day, thus opening to the world the doors of a new art and industry. To-day there are in the United States more than 41,000,000 of these lamps, connected to existing central station circuits in active operation.

Such circuits necessarily imply the existence of central stations with their equipment. Until the beginning of 1882, there were only a few arc lighting stations in existence for the limited distribution of current. At the present time there are over 5,000 central stations in this country for the distribution of electric current for light, heat, and power, with capital obligations amounting to not less than $1,000,000,000. Besides the above-named 41,000,000 incandescent lamps connected to their mains, there are about 500,000 arc lamps and 150,000 motors, using 750,000 horse-power, besides countless fan motors and heating and cooking appliances.

When it is stated that the gross earnings of these central stations approximate the sum of $225,000,000 yearly, the stupendous import of these statistics of an art that came so largely from Mr. Edison's laboratory less than thirty years ago, will undoubtedly appeal to the thoughtful reader in a forcible manner.

But the above are not by any means all the facts relating to incandescent electric lighting in the United States, for in addition to central stations there are upward of 100,000 isolated or private plants in mills, factories, steamships, hotels, theaters, etc., owned by the persons or concerns who operate them. These plants represent an approximate investment of $500,000,000, and the connection of not less than 25,000,000 incandescent lamps, or their equivalent.

Then there are the factories where these incandescent lamps are made, about forty in number, representing a total investment that may be approximated at $25,000,000. It is true that many of these factories are operated by other than the interests which came into control of the Edison patents (General Electric Company), but the 150,000,000 incandescent electric lamps now annually made are broadly covered in principle by Mr. Edison's fundamental ideas and patents.

It will be noted that these figures are all in round numbers, but they are believed to be well within the mark, being primarily founded upon the special reports of the Census Bureau issued in 1902 and 1907, with the natural increase from that time computed by experts who are in position to obtain the facts. It would be manifestly impossible to give exact figures of such a gigantic and swiftly-moving industry, as the totals increase from week to week.

The reader will naturally be disposed to ask whether it is intended to claim that Mr. Edison has brought about all this magnificent and wonderful growth of the electric lighting art. The answer to this is decidedly in the negative, for the fact is that he laid some of the foundation and erected a building thereon, and in the natural progressive order of things other inventors of more or less fame have added a wing here and a story there until the resultant great structure has attained such magnificent proportions as to evoke the wonder and amazement of the beholder; but the old foundation and the fundamental building still remain to support other parts. In other words, Mr. Edison created the incandescent electric lamp, and invented certain broad and fundamental systems of distribution of current, with all the essential devices of detail necessary for successful operation. These formed the foundation. He also spent great sums of money and devoted several years of patient labor and assiduous toil in the early practical exploitation of the dynamo and central station and isolated plants, often under adverse and depressing circumstances, with a dogged determination that outlived an opposition which steadily threatened defeat. These efforts resulted in the firm commercial establishment of his system, which represents the structure built by him on the foundation so well laid. It is true that many important inventions of others have a most distinguished place in the art as it is exploited to-day, but the fact remains that the broad essentials, such as the incandescent lamp, systems of distribution, and some important details, are not only universally used, but are as necessary to-day for successful commercial practice as they were when Mr. Edison invented them many years ago.

The electric railway next claims our consideration, but we are immediately confronted by a difficulty which seems insurmountable when we attempt to formulate any definite estimate of the value and influence which Mr. Edison's pioneer work and inventions bear to the vast proportions of this industry in these later days. There is one incontrovertible fact, namely, that he was the first man to devise, construct, and operate from a central station a practicable, life-size electric railroad, which was capable of transporting and did transport passengers and freight at variable speeds over varying grades, and under complete control of the operator. These are the essential elements in all electric railroading of the present day; and while Mr. Edison's original broad ideas are embodied in present practice, the perfection of the modern electric railway is also greatly due to the labors and inventions of a large number of other well-known inventors. There was no reason why Mr. Edison could not have continued the commercial development of the electric railway after he had helped to show its practicability in 1880, 1881, and 1882, just as he had completed his lighting system, had it not been that the financial men of the period lacked faith in the possibilities of electric railroads, and therefore declined to furnish the money necessary for the purpose of carrying on the work.

With these facts in mind, we shall ask the reader to assign to Mr. Edison a due proportion of credit for his pioneer and basic work in relation to the prodigious development of electric railroading that has since taken place. The statistics of 1908 for American street and elevated railways show that within twenty-five years the electric railway industry has grown to embrace 38,812 miles of track on streets and for elevated railways, operated under the ownership of 1,238 separate companies, whose total capitalization amounted to the enormous sum of $4,123,834,598 in 1908. In the equipments owned by such companies there are included 68,636 electric cars and 17,568 trailers and others, making a total of 86,204 of such vehicles. These cars and equipments earned over $425,000,000 in 1907, in giving the public transportation, at a cost, including transfers, of a little over 3 cents per passenger, for whom a 15-mile ride would be possible. No cheaper transportation is given in the world.

Some mention should also be made of the great

* From the forthcoming "Life of Edison." Copyright, 1908, by Harper & Bros.

electrical works of the country, in which the dynamos, motors, and other varied paraphernalia are made for electric lighting, electric railway and other purposes. The greatest of these works is undoubtedly that of the General Electric Company at Schenectady, New York, a continuation and enormous enlargement of the shops which Mr. Edison established there in 1886. This plant at the present time embraces over 275 acres, of which 60 acres are covered by 50 large and over 100 small buildings; besides which the company also owns other large plants elsewhere, representing a total investment approximating the sum of $34,850,000 up to 1908. The productions of the General Electric Company alone, as shown by average annual sales of over $50,000,000, are of themselves a colossal item, but they do not comprise the total of the country's manufactures in these lines, which amount to five times as much again.

Turning our attention now to the telephone, we again meet a condition that calls for thoughtful consideration before we can properly appreciate how much the wonderful growth of this industry owes to Mr. Edison's inventive genius. In another place there has already been told the story of the telephone, from which we have seen that to Alexander Graham Bell is due the broad idea of transmission of speech by means of an electrical circuit; also that he invented appropriate instruments and devices through which he successfully accomplished this result, although not to that extent which gave promise of any great commercial practicability for the telephone as it then existed. While the art was in this inefficient condition, Mr. Edison went to work on the subject and in due time, as we have already learned, invented and brought out the carbon transmitter, which is universally acknowledged to have been the needed device that gave to the telephone the element of practicability that made it a commercial possibility, and has since led to its phenomenally rapid adoption and world-wide use. It matters not that others were working in the same direction. Mr. Edison was legally adjudicated to have been the first to succeed in point of time, and his inventions were put into actual use, and may be found in every one of the 7,000,000 telephones which are estimated to be employed in the country at the present day. Basing our statements upon facts, shown by the Census reports of 1902 and 1907, and adding thereto the growth of the industry since that time, we find on a conservative estimate that at this writing the investment has been not less than $800,000,000 in now existing telephone systems, and no fewer than 10,500,000,000 talked over the lines during the year 1908. These figures relate only to telephone systems, and do not include any details regarding the great manufacturing establishments engaged in the construction of telephone apparatus, of which there is an annual production amounting to at least $15,000,000 per annum. Surely, in the face of these figures, superlatives would be diminutives in attempting to show further, if it were necessary, the importance of this particular invention.

Leaving the telephone, let us now turn our attention to the telegraph, and endeavor to show as best we can some idea of the measure to which it has been affected by Mr. Edison's inventions. Although, as we have seen in a previous part of this book, his earliest fame arose from his great practical work in telegraphic inventions and improvements, there is no way in which any definite computation can be made of the value of his contributions in the art except, perhaps, in the case of his quadruplex, through which alone it is estimated that there has been saved from $15,000,000 to $20,000,000 in the cost of line construction in this country. If this were the only thing that he had ever accomplished, it would entitle him to consideration as an inventor of note. The quadruplex, however, has other material advantages, but how far they and the natural growth of the business have contributed to the now gigantic investment and earnings of the telegraph companies, is beyond practicable computation.

It would, perhaps, be interesting to speculate upon what might have been the growth of the telegraph and the resultant benefit to the community had Mr. Edison's automatic telegraph inventions been allowed to take their legitimate place in the art, but we shall not allow ourselves to indulge in flights of fancy, as the value of this chapter rests not upon conjecture, but only upon a basis of actual fact. Nor shall we attempt to offer any statistics regarding Mr. Edison's numerous inventions relating to telegraphs and kindred devices, such as stock tickers, relays, magnets, rheotomes, repeaters, printing telegraphs, messenger calls, etc., on which he was so busily occupied as an inventor and manufacturer during the ten years that commenced with January, 1869. The principles of many of these devices are still used in the arts, but have become so incorporated with other devices as to be inseparable, and cannot now be dealt with as separate businesses. To show what they mean, however, it might be noted that New York city alone has 3,000 "tickers," consuming 50,000 miles of record tape every year.

Turning now to other important arts and industries which have been created by Mr. Edison's inventions, and in which he is at this time taking an active personal interest, let us make a visit to Orange, N. J. When his present laboratory was nearing completion in 1887, he wrote to Mr. J. Hood Wright, a partner in the firm of Drexel, Morgan & Co.: "My ambition is to build up a great industrial works in the Orange Valley, starting in a small way and gradually working up."

In this immense plant which represents an investment approximating the sum of $4,000,000 are grouped a number of industrial enterprises, of which Mr. Edison is either the sole or controlling owner and the guiding spirit. These enterprises are the National Phonograph Company, the Edison Business Phonograph Company, the Edison Phonograph Works, the Edison Manufacturing Company, the Edison Storage Battery Company, and the Bates Manufacturing Company. The importance of these industries will be apparent when it is stated that in this plant there are upward of 3,600 people employed, and an annual payroll of about $2,250,000.

In considering the phonograph in its commercial aspect, and endeavoring to arrive at some idea of the world's estimate of the value of this invention, we feel the ground more firm under our feet, for Mr. Edison has in later years controlled its manufacture and sale. It will be remembered that the phonograph lay dormant, commercially speaking, for about ten years after it came into being, and then later invention reduced it to a device capable of more popular utility. A few years of rather unsatisfactory commercial experience brought about a reorganization, through which Mr. Edison resumed possession of the business. It has since been continued under his general direction and ownership, and he has made a great many additional inventions tending to improve the machine in all its parts.

The uses made of the phonograph up to this time have been of four kinds, generally speaking: first, and principally, for amusement; second, for instruction in languages; third, for business, in the dictation of correspondence; and fourth, for sentimental reasons in preserving the voices of friends. No separate figures are available to show the extent of its employment in the second and fourth classes, as they are probably included in machines coming under the first subdivision. Under this head we find that there have been upward of 1,310,000 phonographs sold during the last twenty years, with and for which there have been made and sold no less than 97,845,000 records of a musical or other character. Phonographic records are now being manufactured at Orange at the rate of 75,000 a day, the annual sale of phonographs and records being approximately $7,000,000, including business phonographs. This does not include blank records, of which large numbers have also been supplied to the public.

The adoption of the business phonograph has not been characterized by the unanimity that obtained in the case of the one used merely for amusement, as its use involves some changes in methods that business men are slow to adopt until they realize the resulting convenience and economy. Although it is only a few years since the business phonograph has begun to make some headway, it is not difficult to appreciate that Mr. Edison's prediction in 1878 as to the value of such an appliance is being realized, when we find that up to this time the sales run up to 5,923 in number. At the present time the annual sales of the business phonographs and supplies, cylinders, etc., is not less than $120,000.

We must not forget that the basic patent of Mr. Edison on the phonograph has long since expired, thus throwing open to the world the wonderful art of reproducing human speech and other sounds. The world was not slow to take advantage of the fact, hence there are in the field numerous other concerns in the same business. It is conservatively estimated by those who know the trade and are in position to form an opinion, that the figures above given represent only about one-half of the entire business of the country in phonographs, records, cylinders, and supplies. The gigantic proportions to which the phonograph business has attained in a comparatively few years form of themselves a more eloquent attestation of the value of the art created by Mr. Edison than volumes of words could express.

Taking next his inventions that pertain to a more recently established but rapidly expanding branch of business that provides for the amusement of the public, popularly known as "moving pictures," we also find a universal recognition of the value of the genius which has been productive of so much of commercial growth. Referring the reader to a previous chapter for a discussion of Mr. Edison's standing as a pioneer inventor in this art, let us glance at the commercial proportions of this young but lusty business, whose ramifications extend to all but the most remote and primitive hamlets of our country.

(To be concluded.)

INFLUENCE OF OVER-VOLTAGE ON THE LIFE OF METALLIC-FILAMENT LAMPS.

THE luminosity of incandescent electric lamps increases slightly when they are first used, and thereafter diminishes continually. It is customary to consider that a lamp is practically spent when its candle-power has fallen to 80 per cent of the original value. The determination of the length of life of a lamp is obviously an economic factor of importance.

Now the life of a lamp depends greatly on variations in the voltage at the leads, and especially on any over-voltage that may occur. It has long been known that a lamp is the more sensitive to variations in voltage, the smaller its specific power consumption (or in other words, the greater its luminous efficiency). For this reason the question of over-voltage assumes particular importance in the case of metallic-filament lamps, whose specific power consumption is much smaller than that of carbon-filament lamps.

H. Remané has investigated the influence of a constant over-voltage on the life of osram lamps. The results obtained by him are shown in the two subjoined tables.

Tension.	Square of Tension.	Energy Consumed.	Luminosity.
1.00	1.00	1.00	1.00
1.05	1.10	1.08	1.21
1.10	1.21	1.17	1.43
1.15	1.32	1.25	1.67
1.20	1.44	1.33	1.93
1.25	1.56	1.42	2.21

In these experiments 144 osram lamps were used, some at the normal tension (put equal to 1.00 in the above table), others at 5, 10, 15, 20, and 25 per cent over-voltage.

For a filament of constant ohmic resistance the electrical energy consumed would be proportional to the square of the tension; in point of fact, since metallic filaments increase in resistance as the temperature rises, the energy consumption increases a little less rapidly (see the third column of the above table). As for the luminosity, it increases very rapidly with the tension, since it is more than doubled by an over-voltage of 25 per cent; a 25-candle-power lamp constructed for 110 volts gives no less than 50 candle-power at 134 volts.

Unfortunately, while an excellent light is thus obtained at only a small increase in current expenditure, the lamp is very rapidly burnt out. This is shown in the second table.

Tension.	Useful Life, Hours.	Quantity of Light.	
		In Arbitrary Units.	In Candle-Power, Hours.
1.00	1800	1.00	55,700
1.05	900	0.61	33,750
1.10	350	0.30	16,700
1.15	210	0.20	11,240
1.20	125	0.13	7,395
1.25	70	0.09	4,723

A 100-volt lamp fed with 120 volts will have to be scrapped after only 125 hours, that is to say after it has given only 13 per cent of the amount of light (luminosity × time) which it is capable of giving under normal conditions. The last column of the second table shows the number of candle-power hours which 32-candle-power osram lamps give under the general voltages.—Cosmos.

EXTRACTION OF POTASH AND SODA FROM MINERALS.

POTASH and soda can be extracted from porphyry, liparite, diorite, syenite, etc., by mixing the finely ground minerals with quicklime and boiling the mixture with water in an open vessel if the rock is already in process of decomposition, or under pressure if the minerals are more stable. The infusion is decanted, filtered under pressure and evaporated to dryness or to the strength of a commercial lye. A specimen of phonolite boiled with lime 12 hours under a pressure of 8 atmospheres yielded all of its alkalies, consisting of 9.2 per cent of potash and 8 per cent of soda, while boiling 36 hours in an open vessel extracted not quite two-thirds of the alkalies.

Caseine Cement.—According to the patented process, the caseine to be used is made weakly alkaline by means of soda lye or potash lye and then exposed, for 24 hours, to a temperature of 140 deg. F. The usual additions are then made, such as lime and water-glass, and finally, to cause quicker resinification, substances containing tannin are added. As such, for the partially converted caseine, small quantities—about 1 per cent—of gallic acid, catechu, or oak tannic acid are employed. The caseine cement thus produced, weakly alkaline and with its small percentage of tannic acid, is used, in the familiar manner, for gluing wood together.

TESTING THE HARDNESS OF METALS.*

A REVIEW OF METHODS IN USE.

THE method of testing the hardness of metals devised by Mr. J. A. Brinell has received very favorable attention from metallurgists in this as well as other countries. In 1900 Mr. Brinell, then chief engineer and technical manager of the Fagersta Iron and Steel Works in Sweden, first made public his method

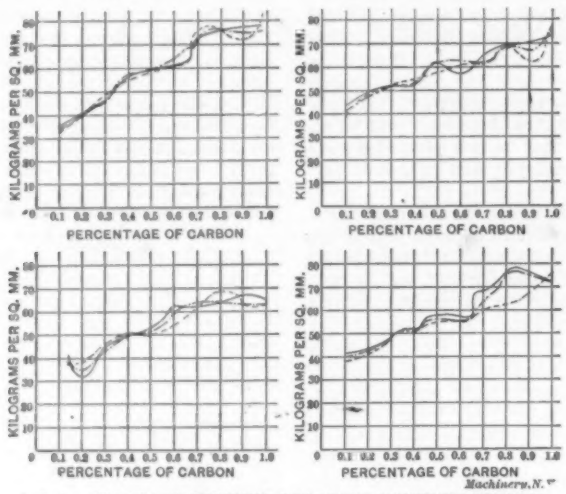


FIG. 1.—DIAGRAMS SHOWING RELATION BETWEEN RESULTS OBTAINED BY VARIOUS METHODS FOR ASCERTAINING THE ULTIMATE STRENGTH OF MATERIALS.

of testing the hardness of iron and steel, by submitting it to the Society of Swedish Engineers in Stockholm. At the meeting of the Congrès International des Méthodes d'Essai des Matériaux de Construction in Paris the same year the method attracted general attention, and its merits were duly acknowledged by rewarding the inventor with a personal Grand Prix at the Paris Exposition. The method was first described in the English language by Mr. Axel Wahlberg in a paper before the Iron and Steel Institute in 1901. Since then the practical value of this method has been amply substantiated on various occasions by means of comprehensive tests and investigations undertaken by several distinguished scientists in different countries. In working out his method, Brinell kept in

PRINCIPLE OF METHOD FOR TESTING HARDNESS OF METALS.

The Brinell method consists in partly forcing a hardened steel ball into the sample to be tested so as to effect a slight spherical impression, the dimensions of which will then serve as a basis for ascertaining the hardness of the metal. The diameter of the impression is measured, and the spherical area of the concavity calculated. On dividing the amount of pressure required in kilogrammes for effecting the impression by the area of the impression in square millimeters an expression for the hardness of the material tested is obtained, this expression or number being called the *hardness numeral*. In order to render the results thus obtained by different tests directly comparable with one another, there has been adopted a common standard as well with regard to the size of ball as to the amount of loading. The standard diameter of the ball is 10 millimeters (0.3937 inch) and the pressure 3,000 kilogrammes (6,614 pounds) in the case of iron and steel, while in the case of softer metals a pressure of 500 kilogrammes (1,102 pounds) is used. Any variation either in the size of the ball or the amount of loading will be apt to occasion more or less confusion without there being any advantage to compensate for such inconvenience. Besides, making any comparisons between results thus obtained in a different manner would be more or less troublesome, and complicated calculation would be required.

The diameter of the impression is measured by means of a microscope of suitable construction, and the hardness numeral may be obtained without calculation directly from the table given herewith, worked out for the standard diameter of ball and pressures mentioned. The formulas employed in the calculation of this table are as follows:

$$y = 2\pi r\,(r - \sqrt{r^2 - R^2}) \qquad (1)$$

$$H = \frac{K}{y} \qquad (2)$$

in which formulas

r = radius of ball in millimeters,
R = radius of depression in millimeters,
y = superficial area of depression in square millimeters,
K = pressure on ball in kilogrammes,
H = hardness numeral.

Suppose, for instance, that the radius of the ball equals 5 millimeters (0.1968 inch), and that the test is undertaken on a piece of steel, the pressure consequently applied being 3,000 kilogrammes (6,614 pounds). Assuming that we found the diameter of the depression equal to 2 millimeters (0.07874 inch) by measurement, we have:

$$2\pi \times 5\,(5 - \sqrt{25 - 4}) = 13.13 = y,$$

and

$$\frac{3{,}000}{13.13} = 228 = H,$$

which, as we see, agrees with the figure given in our table for a 4 millimeters diameter of impression.

RELATION BETWEEN HARDNESS OF MATERIALS AND ULTIMATE STRENGTH.

It has been pointed out by Mr. Brinell himself that this method of testing hardness of metals offers a most ready and convenient means of ascertaining within close limits the ultimate strength of iron and steel. This, in fact, is one of the most interesting and important results of this method of measuring hardness. In order to determine the ultimate strength of iron and steel, it is only necessary to establish a constant coefficient determined by experiments which serves as a factor by which the hardness numerals are multiplied, the product being the ultimate strength. Rather comprehensive experiments were undertaken with a considerable number of specimens of annealed material obtained from various steel works for the purpose of establishing the coefficient by the present director of the Office for Testing Materials of the Royal Technical Institution at Stockholm. The results obtained were as follows:

For hardness numerals below 175, when the impression is effected transversely to the rolling direction, the coefficient equals 0.362; when the impression is effected in the rolling direction, the coefficient equals 0.354.

For hardness numerals above 175, when the impres-

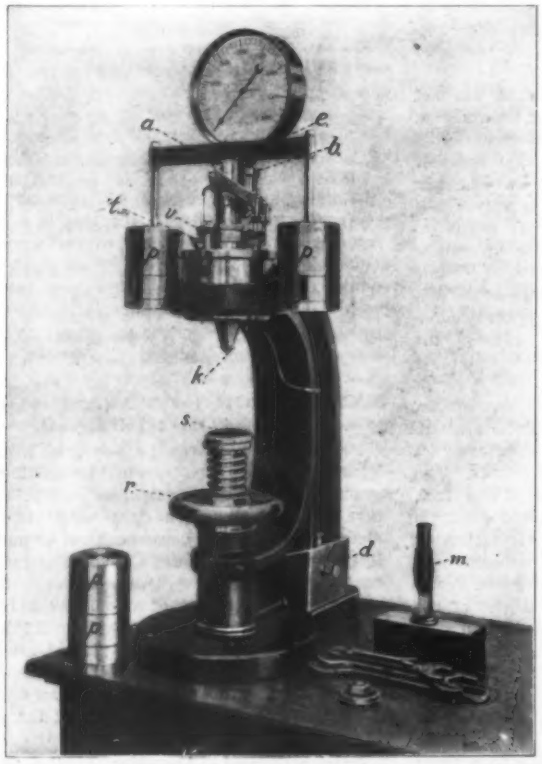


FIG. 2.—AKTIEBOLAGET ALPHA'S MACHINE FOR TESTING HARDNESS OF MATERIALS.

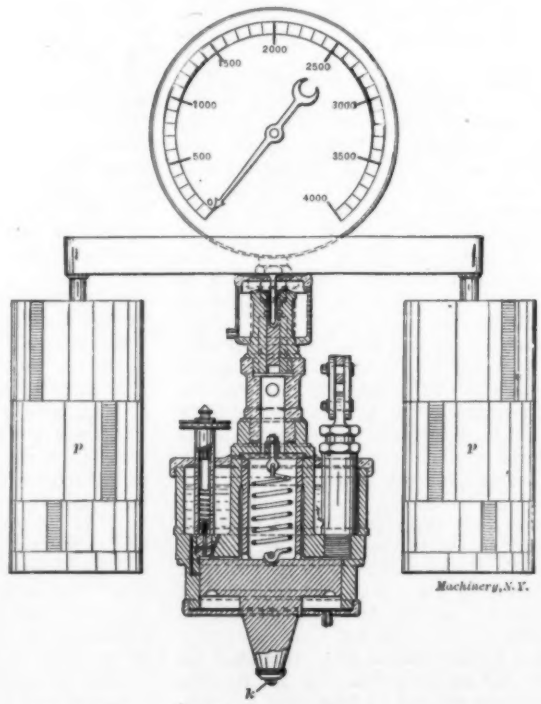


FIG. 3.—SECTION OF PRESS CYLINDER OF MACHINE IN FIG. 2.

view the necessity of taking into account the requirements that the method must be trustworthy, must be easy to learn and apply, and capable of being used on almost any piece of metal, and particularly, to be used on metal without in any way being destructive to the sample.

* That portion of this paper and its illustrations relating to the Brinell method is republished by courtesy of Machinery (New York).

sion is effected transversely to the rolling direction, the coefficient equals 0.344; when the impression is effected in the rolling direction, the coefficient equals 0.324.

If the hardness numerals are multiplied by these coefficients, the result obtained will be the ultimate tensile strength of the material in kilogrammes per square millimeter. It is evident that coefficients can easily be worked out so that if the hardness numerals be multiplied by these the strength could be obtained in pounds per square inch. Suppose, for instance, that a test of an annealed steel bar by means of the Brinell ball test gave an impression of a diameter of 4.6 millimeters. Then the hardness numeral, according to our table, would be 170, and the ultimate tensile strength consequently $0.362 \times 170 = 61.5$ kilogrammes per square millimeter, provided the impression was effected transversely to the rolling direction.

TABLE OF HARDNESS NUMERALS.

Steel ball of 10 millimeters diameter.

Diameter of Impression, Millimeters.	Hardness Numeral. Pressure, Kilogrammes.		Diameter of Impression, Millimeters.	Hardness Numeral. Pressure, Kilogrammes.	
	3000	500		3000	500
2.00	946	158	4.50	179	29.7
2.05	898	150	4.55	174	29.1
2.10	857	143	4.60	170	28.4
2.15	817	136	4.65	166	27.8
2.20	782	130	4.70	163	27.2
2.25	744	124	4.75	159	26.5
2.30	713	119	4.80	156	25.9
2.35	683	114	4.85	153	25.4
2.40	652	109	4.90	149	24.9
2.45	627	105	4.95	146	24.4
2.50	600	100	5.00	143	23.8
2.55	578	96	5.05	140	23.3
2.60	555	93	5.10	137	22.8
2.65	532	89	5.15	134	22.3
2.70	512	86	5.20	131	21.8
2.75	495	83	5.25	128	21.5
2.80	477	80	5.30	126	21
2.85	460	77	5.35	124	20.6
2.90	444	74	5.40	121	20.1
2.95	430	73	5.45	118	19.7
3.00	418	70	5.50	116	19.3
3.05	402	67	5.55	114	19.
3.10	387	65	5.60	112	18.6
3.15	375	63	5.65	110	18.2
3.20	364	61	5.70	107	17.8
3.25	351	59	5.75	105	17.5
3.30	340	57	5.80	103	17.2
3.35	332	55	5.85	101	16.9
3.40	321	54	5.90	99	16.6
3.45	311	52	5.95	97	16.2
3.50	302	50	6.00	95	15.9
3.55	293	49	6.05	94	15.6
3.60	286	48	6.10	92	15.3
3.65	277	46	6.15	90	15.1
3.70	269	45	6.20	89	14.8
3.75	262	44	6.25	87	14.5
3.80	255	43	6.30	86	14.3
3.85	248	41	6.35	84	14.
3.90	241	40	6.40	82	13.8
3.95	235	39	6.45	81	13.5
4.00	228	38	6.50	80	13.3
4.05	223	37	6.55	79	13.1
4.10	217	36	6.60	77	12.8
4.15	212	35	6.65	76	12.6
4.20	207	34.5	6.70	74	12.4
4.25	202	33.6	6.75	73	12.2
4.30	196	32.6	6.80	71.5	11.9
4.35	192	32	6.85	70	11.7
4.40	187	31.2	6.90	69	11.5
4.45	183	30.4	6.95	68	11.3

In Fig. 1 are shown a number of diagrams which indicate the results obtained at the tests undertaken to ascertain the coefficients given. In these diagrams the full heavy line indicates the tensile strength of the material, as calculated from the ball tests in the rolling direction. The dotted lines indicate the strength as calculated from the ball tests in a transversal direction, and the "dash-dotted" lines show the actual tensile strength of the material as ascertained by ordinary methods for ascertaining this value. It is interesting to note how closely the three curves agree with one another, and considering the general uncertainty and variation met with when testing the same kind of material for tensile strength by the ordinary methods, it is safe to say that the ball test method comes nearly as close to the actual results as does any other method used. Especially within the range of the lower rates of carbon, or up to 0.5 per cent, or in other words, within the range of all ordinary construction materials, the coefficients are, in fact, so very nearly perfect as to be amply sufficient to satisfy all practical requirements.

In the case of any steel, whether it be annealed or not, that has been submitted to some further treatment of any other kind than annealing, such as cold working, etc., or in the case of any special steel, there would be other coefficients needed which would then also be ascertained by experiments. The same coefficient, however, will hold true for the same kind of material having been subjected to the same treatment. Thus, the ball testing method for strength is equally satisfactory, and far more convenient, in all cases where the rupture test would be applied. One of the greatest advantages of the Brinell method is that in the case of a large number of objects being required to be tested, each one of the objects can be tested without demolition, and without the trouble of preparing test bars.

APPLICATION OF THE BRINELL BALL TEST METHOD.

Summarizing what has been said in the previous discussions, and adding some other important points, we may state the various uses for which the Brinell ball test method may be applied, outside of the direct test of the hardness of constructing materials and the calculation from this test of the ultimate strength of the materials, as follows:

1. Determining the carbon content in iron and steel.

2. Examining various manufactured goods and objects, such as rails, tires, projectiles, armor plates, guns, gun barrels, structural materials, etc., without damage to the object tested.

3. Ascertaining the quality of the material in finished pieces and fragments of machinery even in such cases when no specimen bars are obtainable for undertaking ordinary tensile tests.

4. Ascertaining the effects of annealing and hardening of steel.

5. Ascertaining the homogeneity of hardening in any manufactured articles of hardened steel.

6. Ascertaining the hardening power of various quenching liquids, and the influence of temperature of such liquids on the hardening results.

7. Ascertaining the effect of cold working on various materials.

MACHINES USED FOR TESTING THE HARDNESS OF METALS BY THE BRINELL METHOD.

The method of applying the Brinell ball test was at first only possible in such establishments where a tensile testing machine was installed. As these machines are rather expensive, the use of the ball test method was limited. For this reason a Swedish firm, Aktiebolaget Alpha, Stockholm, Sweden, has designed and placed on the market a compact machine specially intended for making hardness tests. This machine, as shown in Fig. 2, consists of a hydraulic press acting downward, the lower part of the piston being fitted with a 10-millimeter steel ball k by means of which the impression is to be effected in the surface of the specimen or object to be tested. This object is placed on the support s which is vertically adjustable by means of the hand-wheel r, while at the same time it can be inclined sideways when this is needed on account of the irregular shape of the part tested. The whole apparatus is solidly mounted on a cast iron stand. The pressure is effected by means of a small hand pump, and the amount of pressure can be read off directly in kilogrammes on the pressure gage mounted at the top of the machine.

In order to insure against any eventual non-working of the manometer, this machine is fitted with a special contrivance purporting to control in a most infallible manner the indications of that apparatus, while at the same time serving to prevent any excess of pressure beyond the exact amount needed according to the case. This controlling apparatus consists of a smaller cylinder, a, directly communicating with the press-cylinder. On being loaded with weights corresponding to the amount of pressure required, the piston in this cylinder will be pushed upward by the pressure effected within the press-cylinder at the very moment when the requisite testing pressure is attained. Owing to this additional device, there can thus be no question whatever of any mistake or any

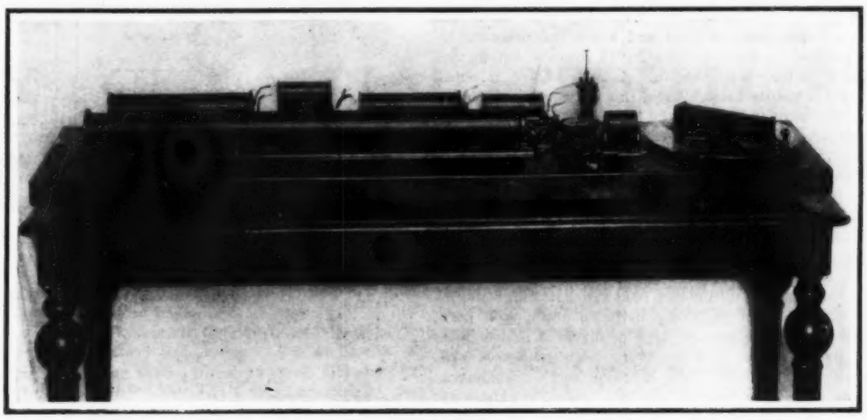


FIG. 6.—ELECTRO-MAGNETIC TESTER FOR HARDNESS ON A TABLE READY FOR SERVICE.

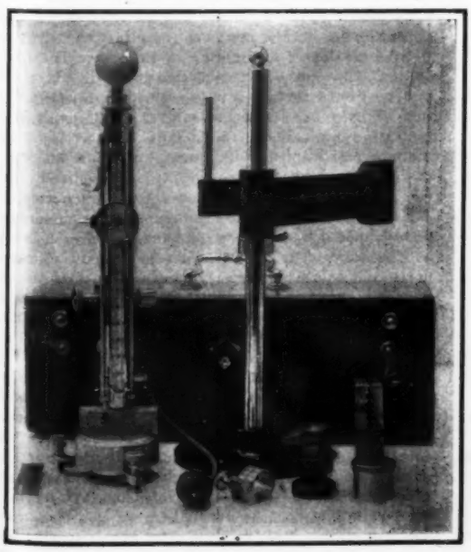


FIG. 4.—THE SCLEROSCOPE, A NEW INSTRUMENT FOR TESTING THE HARDNESS OF METALS.

FIG. 5.—THE REBOUND OF A POINTED WEIGHT DROPPED ON THE SPECIMEN REGISTERS THE INSTANTANEOUS RESISTANCE OF THE LATTER TO DEFORMATION.

TESTING THE HARDNESS OF METALS.

errors as to the testing results, that might eventually be due to the manometer getting out of order.

METHOD OF PERFORMING THE BALL TEST.

The test specimen must be perfectly plane on the very spot where the impression is to be made. It is then placed on the support *s*, Fig. 2, which, as mentioned, is adjusted by means of the hand-wheel *r* so as to come into contact with the ball *k*. A few slow strokes of the hand pump will then cause the pressure needed to force the ball downward, and a slight impression will be obtained in the object tested, but as soon as the requisite amount of pressure has been attained, the upper piston is pushed with the controlling apparatus upward, as previously described. On testing specimens of iron and steel, the pressure is maintained on the specimen for 15 seconds, but in the case of softer materials for at least half a minute. After the elapse of this time, the pressure is released, and the contact between the ball and the sample will cease. A spiral spring fitted within the cylinder, and being just of sufficient strength to overcome the weight of the press piston, pulls the same upward into its former position, while forcing the liquid back into its cistern. The diameter of the impression effected by the ball is then measured by the microscope *m*, which is specially constructed for this purpose, the results obtained by this measurement being exact within 0.05 millimeter (0.002 inch). Fig. 3 shows a cross-section through the cylinder and piston part of the machine. Another type of machine is designed for special tests in which very high pressures are required. The ball in this machine is 19 millimeters (0.748 inch) in diameter, and the pressures employed vary from 3 to 50 tons. The construction and operation are otherwise exactly the same as that of the smaller machine in Fig. 2.

THE HAMMER METHOD OF TESTING FOR HARDNESS.

Mr. Albert F. Shore has devised a new method of testing which comes into direct competition with the Brinell method. As we have seen, the Brinell method proceeds by the slow pressure of a ball upon the surface to be tested. The amount of permanent compression is taken as indicating the lack of hardness—or, expressed differently, as indicating by its reciprocal the degree of hardness. Thus, the deeper the permanent indentation, other things being equal, the softer the metal. It is to be noticed particularly, that it is not the original deformation that is relied on, but the permanent one. These matters of slowness and permanency would appear to be mutually corrective. Thus, by slow compression we should effect a deeper indentation. But, as recovery is allowed, and only the permanent indentation measured, the deformation would have a tendency to recover. At any rate, the Brinell method has proved itself of advantage during a considerable period of trial, and Mr. Shore's method would appear to correspond well with it; for comparative tests have been made, disclosing for the most part a rather striking agreement between the two methods.

Mr. Shore's instrument, called the scleroscope, consists essentially of a tiny weight pointed at one end, a piece of glass tubing, and a scale of measurements. The weight fits inside the tube, which serves as a guide. Upon holding the tube upright and allowing the weight to fall, pointed end downward, a sharp blow will be struck upon any specimen placed in position. A scale, graduated from 0 to 140, is placed behind the tube. Upon this scale, the rebound is measured. Referring to Fig. 4 the glass tube may readily be seen held in position by a standard on the left. The rod seen to the right of the tube swings freely from its upper end, and is, in fact, a plumb rod, employed for the purpose of enabling the operator to hold the instrument in a vertical position. The bulb seen at the top is used to exhaust the air from the tube and thus raise the weight. Once in position at the top of the tube the weight is detained by a suitable catch. When it is desired to operate the instrument, the finger hook seen on the left is pressed down and the bulb lying on the table is compressed. The weight is now released and free to fall.

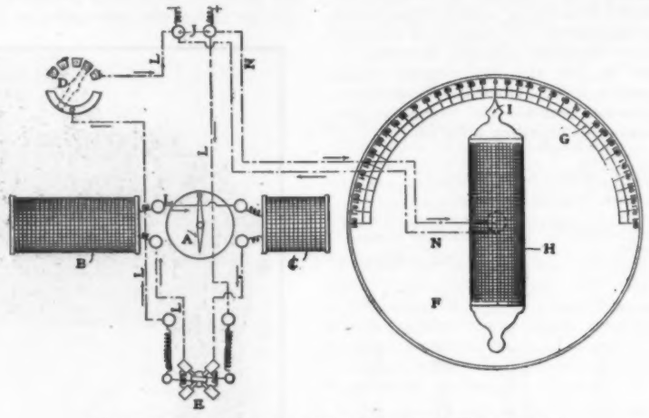


FIG. 8.—SHOWING DETAILS OF ELECTRICAL CONNECTIONS.

The specimen to be tested should present a horizontal surface at the lower end of the tube. If it is of suitable size and shape it may be held in a clamp. If of irregular form, it may be imbedded in a composition of tar and asphaltum. This material affords in itself an illustration of hardness in reference to a quick blow. For it supports the specimen when subjected to the instantaneous impact with little or no yield, although the specimen may be imbedded in it with no trouble.

If the piece to be tested is large or if it is inconvenient to remove it from its position, the essential part of the instrument may be disengaged from its base, and used separately. This is a matter of great convenience. Thus, by opening a bearing box, both shaft and box may be tested. If the brasses are harder than the steel, it is a combination which may produce trouble; for should the bearing at any time become dry, the shaft would be cut.

By following out the line of procedure suggested by this illustration, a manufacturer will be able to assemble the parts of a machine on the principle of combining with a more expensive piece a softer, less expensive one, so that when wear takes place the less valuable part may be the one to suffer instead of the other. Likewise, the part removable at greater trouble may be associated with a softer and more easily removable piece. These principles are of great value in machine construction, and need only to be mentioned to be understood.

At present two styles of hammer are used in the scleroscope—one with rather a sharp point, the other somewhat more blunted. The sharp-pointed weight strikes a blow of 75,000 pounds to the square inch. As the weight is quite small, it is necessary, in order to secure this result, that but a very minute area shall be in actual contact. Great difficulty was experienced in securing a material suited for such exacting service. The diamond was tried, but failed. Finally, using the scarcely perfected instrument itself in the effort for success, a method of treating steel was devised which enables the manufacturer to produce a weight capable of withstanding such a tremendous shock upon a very small point. When the hammer, after falling freely for about ten inches, strikes the surface of a fine grade of hardened steel, it rebounds about seven inches. As the scale is divided into 140 parts, such steel registers about 100 points. This rebound is sufficient to enable a distinction to be made between steels differing but slightly in hardness. Thus the fine grades of hardened pure carbon tool-steel range from 90 to 110 points. The same steels, unhardened, disclose a hardness of 40 to 50 points, if unannealed. If annealed properly, the hardness drops to about 31 points. Now the lower carbon steel (as railway rails) annealed show a hardness of about 26 to 30. Brass may be as hard as 30 or it may fall as low as 12. Wrought iron has been found to be 18 hard, while zinc and copper but 8 and 6, respectively. Turning to the alloy-steels, we find manganese self-hardening steel showing a hardness of 60 to 85. High-speed tool-steel, hardened, discloses an instantaneous resistance equal to 100 to 105. This seems to indicate that the finest pure carbon tool steel may be made harder than the alloy steel. But there are so many varieties and grades, and variations in handling, that we must not regard these figures as settling once for all the comparative hardness of these two important kinds of tool steel.

An interesting matter is the effect of compression. This seems, almost without exception, to increase the hardness of the metal. Thus wrought iron increases from 18 when in ordinary condition to 30 when compressed. Lead, which is, of course, very far down in the scale, varies from 2, uncompressed, to 3, compressed. But zinc shows the remarkable variation from 8 to 20—150 per cent increase. Hard brass, 30, may be made still harder by compressing its particles.

Besides the methods and instruments described, there is also an electrical way of testing the hardness of steel. This apparatus has been designed by Prof. D. E. Hughes. One of the laws governing ferro-magnetic bodies states that the magnetic capacity is directly proportional to the softness or molecular freedom; and another law, which holds good for iron and steel, that the resistance to a feeble external magnetic force is directly as the molecular rigidity or hardness.

By means of the magnetic balance it is shown that annealing not only produces softness in iron, but frees it from strains of hammering or drawing. The illustration, Fig. 6, shows the electro-magnetic tester for hardness on a table ready for service, while illustration, Fig. 7, shows a top view of the coils, scale, and indicating mechanism, the details of electrical connections being noted in diagram, Fig. 9. In operating this instrument it is made perfectly horizontal by the use of two spirit levels indicated in the plan view in Fig. 7 near the center, the adjusting screw under the plate or board, seen in Fig. 6, being raised or lowered as necessary. The magnetic needle is made to point north and south by properly locating the instrument, and the glass cover is placed over the needle and dial in order to avoid the effects of currents of air. The coils *B* and *C* in the diagram, Fig. 8, are held to the metal frame or plate by bolts passing through the slots indicated in the plan, Fig. 7. These solenoids may be moved toward the magnetic needle or away from it, in order to increase or decrease the magnetic force, and a rheostat *D* is provided for regulating the current, a commutator *E* being placed in front of the magnetic needle *A*, this switch *E* being utilized to reverse the current through the solenoids.

There is a compensator *F*, consisting of a large copper disk divided into the scale *G*, of 180 parts for each quarter. This disk is seen at the right of the small solenoid *C* in the diagram, Fig. 8, and the plan, Fig. 7, an electro-magnet *H* being mounted on top of the

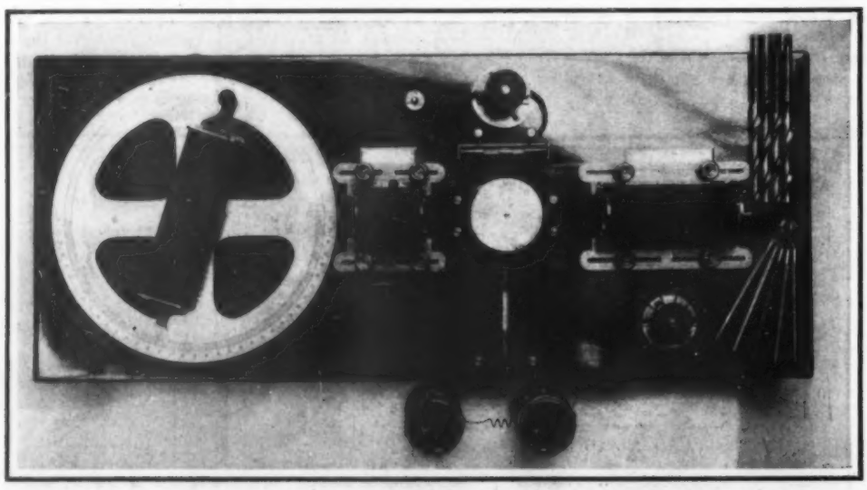


FIG. 7.—ELECTRO-MAGNETIC TESTER FOR HARDNESS. TOP VIEW OF THE COILS, SCALE, AND INDICATING MECHANISM.

TESTING THE HARDNESS OF METALS.

disk and provided with an indicator *I* for use on the circular scale in reading the same. A battery current of 3 to 8 volts is utilized, the force of the current being determined by a galvanometer.

The piece of steel to be tested is placed in the instrument after the indicator *I* has been placed at zero, and then the current is sent through the solenoid, and they are moved away from the magnetic needle or toward it until it rests at zero, when the current is reversed by the switch *E*, the instrument being tested for true balance.

In the center of the solenoid *B* the piece of steel or projectile is inserted, and when the current is turned on, the needle will move on account of the test piece disturbing the balance of the instrument by becoming magnetized. It is then necessary to move the electro-magnet *A*, so as to establish a magnetic equilibrium by bringing the magnetic needle to the zero. A record is made of the reading, and the current is reversed through the solenoids, a second reading being made when the electro-magnet is moved in the opposite direction, to bring the magnetic needle back to zero.

The magnetic capacity of the test piece of steel or projectile is obtained by adding the two readings on the indicator *I*, but in determining the magnetic capacity by passing the current through the piece direct or reverse, it must not have any of the artificial magnetism given to it by tempering or by forging.

It is stated that the locks on gun barrels have been tested by this instrument in Europe, more than one hundred pieces being tested per hour. It is held that by means of this instrument degrees of temperature for tempering and hardening were determined which practically abolished the faults before encountered, where a great many pieces were split and broken, causing great annoyance. In Europe the testing of projectiles by means of this instrument has been successful, a sliding carriage being provided for inserting the shell into the solenoid. Of course, this instrument is limited to testing the hardness of iron and steel, and cannot be used for determining this quality in metals of a non-ferrous nature.

THE EFFICIENCY OF AERIAL PROPELLERS.

A NEW INVESTIGATION AND ITS RESULTS.

BY W. R. TURNBULL.

IN the December 19th, 1908, issue of the SCIENTIFIC AMERICAN SUPPLEMENT, Mr. Sidney H. Hollands writes of a new form of aerial propeller in a rather misleading way. He states, "The propeller tested was of 6 feet diameter, and as little as 1 brake-horse-power sufficed to drive it at 370 revolutions per minute. The carefully measured thrust at this speed was 26½ pounds. The volume of air displaced was 40,000 cubic feet per minute, and the linear velocity of the air column was 1,400 feet per minute. *Let it be borne in mind that this was at a speed of only 370 revolutions per minute, a low speed for a 6-foot propeller of this type.*"

The italics are mine, for it is just at this point that Mr. Hollands's remarks are misleading. If he had given us the efficiency of his propeller at double or triple the speed the efficiency would show a thrust of about 18 pounds and 12 pounds respectively per brake-horse-power.

This is a very good screw indeed, but the average 6-foot two-blade aerial propeller, with concave blades of about 1/12 curvature, the chords of the concavity showing a true screw, is quite capable of giving 22 pounds thrust per brake-horse-power at 370 revolutions, as will be clearly seen from the accompanying curve (see figure). It is hardly fair for Mr. Hollands to compare his 26½ pounds thrust with the 9 pounds of Maxim's propellers, the 7 pounds of Langley's, the 6 pounds of Farman's, etc., without giving their speeds of rotation. Mr. Hollands does not tell what the efficiency of his propeller is at 1,000 revolutions per minute (for instance) and does not point out the crux of the whole question of the efficiency of all aerial propellers of rational design.

The whole question of efficiency of two-blade aerial propellers is one of diameter and speed.

Speaking always of properly designed concave propellers, a propeller of large diameter and slow speed is always the most efficient (other things being equal). Reduce the diameter and increase the speed and the efficiency steadily drops from about 50 pounds thrust per horse-power to about 6 pounds per horse-power (to use concrete examples within the range of ordinary experiments).

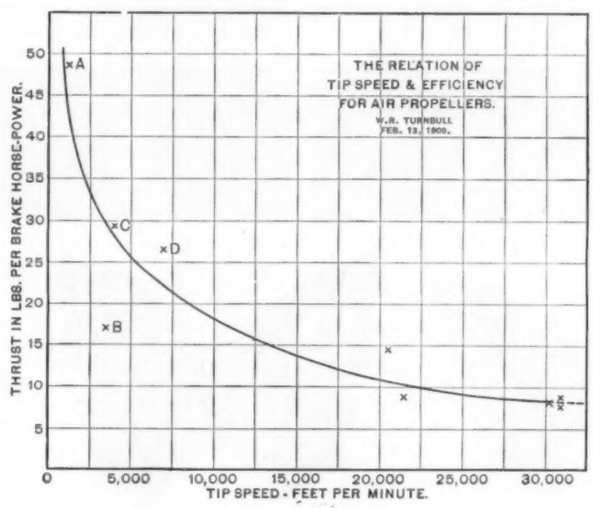
The Frenchmen have constantly erred on this point, using a single propeller of 6 to 7 feet in diameter at about 1,100 revolutions per minute and 50 horse-power, as against the Wrights' two propellers turning up about half that speed with 25 horse-power; and it is just in this vital point of design that the higher efficiency of the Wright machine has been demonstrated.

Theoretically, an aeroplane or dirigible should have propellers of very large diameter turning at a comparatively low speed, but in the case of the aeroplane especially the diameter of the propellers must be reduced to conform to the general design and it is this serious compromise that is the greatest drawback of the present-day aeroplane machine.

Langley demonstrated that 1 horse-power, properly applied, could carry 200 pounds at 40 miles per hour. But what machine approaches this?

Theoretically, according to this, the Wright machine should be supported by a 5-horse-power engine (instead of a 25-horse-power one) or say 7 horse-power to overcome the resistance of the necessary supports, but this would entail propellers of large diameter and pitch, turning at a slow speed, and they are not compatible with the rest of the design. If they were, what a tremendous saving would be effected! The engine weight would be reduced to one-third and the "steaming radius" of the machine increased threefold.

I can quite indorse Mr. Hollands's remarks concerning the advantages of the two-bladed propeller for aerial work, but from my own experiments I feel confident that if the blade area is from 10 to 15 per cent of the area swept, if the blades are made with a concave curvature (of about 1/15) and with a slightly increasing pitch, if the ratio of diameter to pitch is from 1 to 1.25, and if the diameter of the propeller is made large and the speed of rotation small, we will have a propeller that approaches the maximum possible efficiency.



The curve shown herewith gives the whole thing in a nutshell. For any propeller, of rational design, the higher the speed the lower the efficiency, and for any type, the larger the diameter the greater the efficiency.

In the curve abscissæ are tip speeds in feet per minute, and the ordinates represent the thrust in pounds per brake-horse-power, thus we have a measure of the efficiency at different speeds. (Note: Diameter in feet multiplied by 3.1416 and by revolutions per minute gives the tip speed in feet per minute.)

Points *A* and *B* are the figures of Renard, published in 1889, for the same propeller of 23 feet diameter, at two different speeds; point *C* is the result of Breguet (1907) for a helicopter screw of 26½ feet diameter, and point *D* Mr. Hollands's propeller. All the other points are for modern high-speed screws of about 5 to 7 feet in diameter, driven at much too high a speed for good efficiency.

The falling off in efficiency at the higher speeds is most remarkable, for while it seems possible with the most efficient screws to get thrusts of 40 or 50 pounds to the horse-power, the modern aeroplane has a screw of one-sixth this efficiency, or about 7 pounds per horse-power.

This particular compromise of using a small-diameter, high-speed screw to suit the rest of the design has cost the present-day aeroplanes an enormous toll, and it is right at this point that the present design is decidedly poor, for it means we have to carry an engine six times heavier than it should be, and that means much larger aeroplanes (with their additional weight) to carry the extra weight of the motor, etc.

Sooner or later we will be forced to study this subject of efficiency if we are to arrive at a practical solution of aerial navigation, and the present indications are that the air-screw is not the ideal means of propulsion, at least for aeroplane machines of the present type.

SAFEGUARDING WOOD AGAINST ANTS.

A NEW process has been discovered for warring against white ants, the pest of the tropics. These termites, as they are called, destroy the woodwork of the finest building within six months. Their action is insidious, inasmuch as the outward appearance of the wood does not betray the rottenness within, and their ravages, if not discovered in time, lead to the total collapse of buildings. No wood except eucalyptus and teak resist the termites. If soft wood is used in tropical countries it must be saturated with kerosene.

After a somewhat practical trial, news has been received from the Madras Presidency that the specimens sent there have successfully resisted the attacks of white ants. The great importance of this new process to India, Australia, South Africa, and other tropical regions can scarcely be overestimated.

The process is extremely simple and adds very little to the cost of the timber. To those who are technically interested in the new process it may be explained that it is one which rapidly seasons newly cut timber, and unlike other systems improves, toughens, and strengthens the wood, enhancing the appearance and resisting the attacks of dry rot, which in temperate countries is the equivalent of termites. This is accomplished by boiling the timber in a saccharine solution, which extracts the air and coagulates the albumen in the sap. In cooling, the air spaces are filled with saccharine matter, which in large measure is analogous to the fiber of timber. The timber is then rapidly dried in fairly high temperatures and becomes a homogeneous vegetable substance which does not expand, warp, contract, or split like ordinary timber.

Preserving Medium for Valuable Printed Matter.—Upon the objects to be protected (stamps, engravings, rare prints, etc.) a 3 per cent collodion solution can be applied without injurious consequences,

EXPERIMENTING WITH ANIMALS AND PLANTS.

STUDIES IN ARTIFICIAL MUTATION.

BY R. FRANCÉ.

For a year or more the scientific journals and newspapers of Europe and America have contained frequent references to Luther Burbank's remarkable experiments in the production of new varieties of plants by hybridization and selection. The name of the "Wizard of Santa Clara" has become almost a household word, and the nucleus of a group of legends of varying character. Some of the published statements are well calculated to awaken the liveliest general interest: for example, the report that Andrew Carnegie has assured to the California wizard an annual stipend of $10,000 for the prosecution of his experiments, and the official statement of the U. S. Department of Agriculture that the introduction of the Luther Burbank potato has increased the value of the annual potato crop of the United States by $17,000,000.

Figures are the best arguments in these days. These statements create the impression that an immense and unprecedented advance in science must have been suddenly made in California. Yet these astounding results are simply practical applications, on a large scale, of the experiments that have been performed in all biological laboratories, and of the "theorizing" which is so contemptuously regarded by "practical" men.

The simple fact is that we are beginning to learn, from the labors of the workers in the theory of development, something of the problem of the origin of species, and we are almost ready to apply our knowledge to the creation of new arts and industries.

The nature of this "applied botany," the scope of its problems and the progress that has been made, will be made clear by a few examples.

A familiar object to every bacteriologist is the "bleeding host" (*Bacillus* or *Micrococcus prodigiosus*, Fig. 1), a harmless bacterium of common occurrence in woodland streams in autumn. It occasionally appears on bread and other articles of food where its color has given rise to superstitious beliefs. Cultivated on slices of boiled potato at ordinary room temperature it soon produces large spots which strikingly resemble fresh blood stains. But if such a culture is heated to the temperature of the blood (98.6 deg. F.) the bacterium is transformed into another species with different properties. In particular, the production of the red pigment is arrested, but it recommences when the culture is exposed to a lower temperature.

This is the simplest example of the control of vital phenomena by the knowledge and regulation of the conditions of life. Experiments of this nature have given rise to a new science—the experimental physiology of the origin of specific characters.

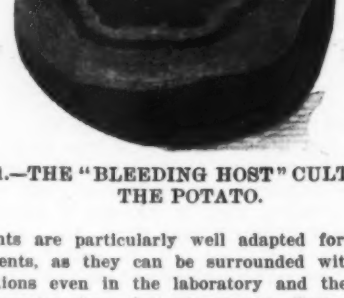


FIG. 1.—THE "BLEEDING HOST" CULTURE ON THE POTATO.

Plants are particularly well adapted for such experiments, as they can be surrounded with natural conditions even in the laboratory and their life is less complex than that of animals. Remarkable results, however, have been obtained with animals. Fischer, Standfuss and other experimenters have artificially produced varieties of butterflies, which in nature are found only in polar or very warm regions, or nowhere on earth. In these experiments, also, the law connecting external temperature with the production of pigment in the metabolism of life was skillfully utilized, although this law is far more complex for butterflies than for bacteria. The following examples are drawn from the genus *Vanessa*, which has been chiefly employed in these experiments and which comprises several of the best known and most beautiful of butterflies, including the peacock butterfly (*Vanessa Io*), the nettle butterfly (*V. urticæ*), the scarlet admiral (*V. Atalanta*, etc.). Fig. 2 shows three peacock butterflies. The first (*a*) was developed normally, while the pupæ of the others were cooled for an hour and a half or two hours, twice daily, on three successive days to 45 or 50 deg. F. The effect of cold is shown especially in the "eyes," which in the specimen (*c*) are scarcely discernible. The brightness of the coloring is also greatly diminished. The first specimen of *Vanessa polychloros* (Fig. 3 *a*) was developed normally. The pupa of the second specimen (*b*) was cooled to 10½ deg. F. twice daily for two hours on three successive days, while the pupa of the third specimen (*c*) was heated thrice in the course of 36 hours to 104 deg. F. In both cases the pattern was greatly changed, the heating, however, having more effect than the cooling.

Thus the possibility of changing one species into another, at least in appearance, was established. The numerous experiments that followed this discovery proved with absolute certainty that ordinary *Vanessa* pupæ, exposed to temperatures between 32 and 50 deg. F., develop into butterflies of types which lived in the ice age or which are now found in the polar regions, while high temperatures, between 95 and 104 deg. F., produce types now found in Corsica and Sardinia, and types which are not now found anywhere, though they may have existed in the infancy of the earth or may appear in future ages.

A third way of approaching the problem of the origin of types was opened by the discovery of the real nature of lichens. It has been proved that these peculiar and often very beautiful vegetable incrustations which are found on every tree and every rock are symbiotic associations of plants of two distinct classes.

The tissue of a lichen, when examined with a microscope, is found to contain elements of two very different kinds: green or blue spheres and transparent threads (Fig. 7). The true nature of the lichen was explained when it was discovered that each of these elements is capable of independent existence. The spheres are algæ, the threads are fungi. The algæ furnish nutriment to the fungi, and the fungi supply water and thus enable the algæ to live out of their natural medium.

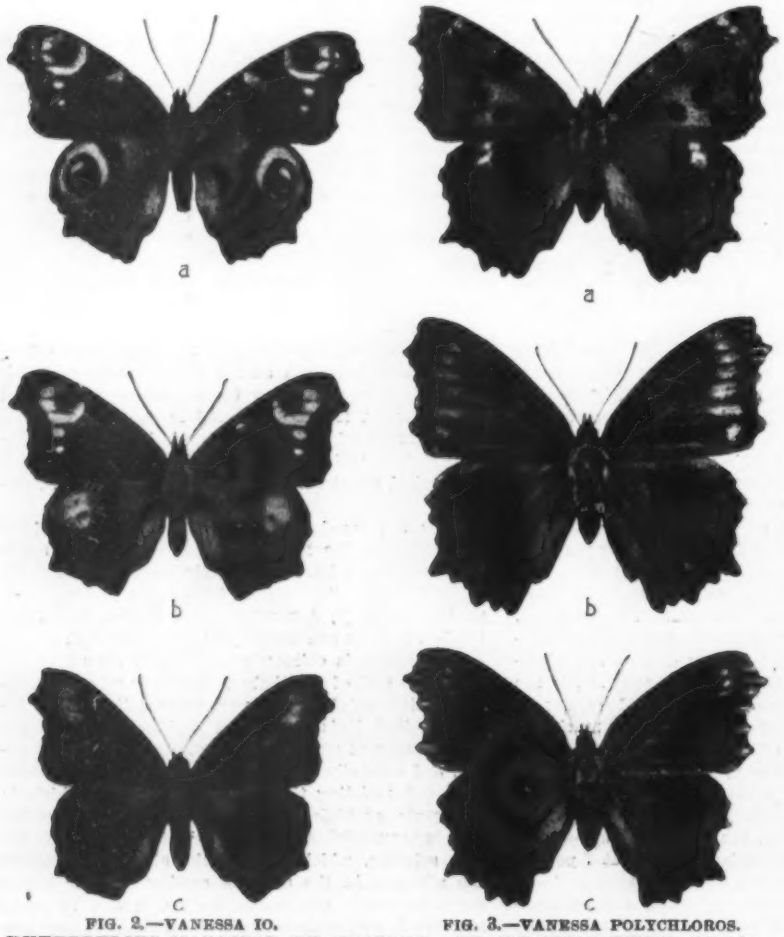


FIG. 2.—VANESSA IO. FIG. 3.—VANESSA POLYCHLOROS.
BUTTERFLIES MODIFIED BY COOLING AND HEATING THEIR PUPÆ.

FIG. 4.—VARIOUS LICHENS.

These facts are well known, but a fact of much greater importance, which is not so well known, is the possibility of producing, by such symbiotic associations of algæ and fungi, new and artificial species of lichens. This possibility opens a prospect of penetrating into the intimate secrets of organic life. Only a beginning has been made, but the method deserves

mention because of the vast and hitherto unsuspected possibilities which it suggests.

Thus scientific investigations, apparently of the most useless character, have brought us nearer to the experimental modification of properties. Another result has been a change in theoretical conceptions of the origin of species and the steady progress of the view that the cause of the manifold variations of

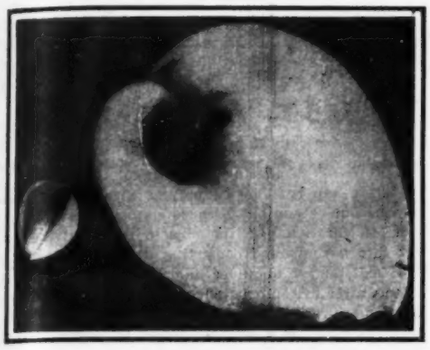


FIG. 5.—BURBANK'S GIANT CALLA AND THE VARIETY FROM WHICH IT WAS DERIVED.

organisms must be sought, not in external conditions, but in the ability of the organism to react to those conditions. This is the basis of all those experiments in the modifications of properties which are beginning to exert a beneficial economic influence.

The most important effect has been produced in the industries dependent upon fermentation, including the manufacture of alcohol, spirits, wine, beer, compressed yeast, and vinegar, by Hansen's discovery that the production of the distinct varieties of the yeast fungus upon which these industries so largely depend is governed by perfectly definite external factors (Figs. 8 and 9). It is impossible to give here even a sketch of the method of development of these numerous varieties of yeast, and it is more to the purpose of this article to mention the three general laws which have been deduced from the experiments.

1. Varieties of yeast are produced, not by selection, but by transformation of qualities, and hence, not by external influences alone, but by forces innate in the yeast plant.

2. The variety of yeast employed exerts a most decisive influence on the quality of the product, especially if this is beer or wine.

3. By taking advantage of the reaction to temperature, and in other ways, the desired varieties of yeast can be produced artificially in a state of purity and on a large scale.

This brings us back to our starting point, for Burbank, in his systematic and widely extended experiments, in many of which many thousands of plants are employed, appears also to utilize the reactive capacity of the plant. Instead of physical factors, however, he generally employs the chemical stimuli introduced by cross-fertilization, which appear to affect the inmost essence of the plant and cause it to develop quite unexpected properties. The perpetuation of valuable and the elimination of undesirable properties are then secured by selection, to which Burbank assigns the humble role of a "sieve" which is given to it by modern botanists in the production of natural species. In Germany, at least, the theory that

FIG. 6.—BURBANK'S SEEDLESS PLUM.

makes natural selection the principal factor in adaptation and the formation of species, is practically obsolete.

Burbank obtained his famous seedless plum (Fig. 6) by selection from 300,000 artificially produced variations, and preserved only one of 5,000 blackberry and apple crosses. Among his other achievements are mulberry and blackberry hybrids of delicious flavor, a smooth-skinned opuntia, or prickly pear cactus, of inestimable value as fodder in arid regions, the enormous Shasta goose plum, the giant calla (Fig. 5), and many other astonishing novelties. He always works with thousands of variations of the type which he is seeking to improve. His superb Santa Rosa rose, which blooms throughout the year, is the result of 15,000 crossings. These figures, perhaps, give the best idea of the latent forces of life and of the possibilities of the new art of applied biology.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Illustrirte Zeitung.

THE SENSE OF HEARING IN INSECTS.

By K. SAJO.

INSECTS do not possess ears at all resembling the ears of mammals and, although certain parts of their bodies are regarded by biologists as organs of hearing, they have not been certainly proved to be such. These organs are found, not in the head, but in the antennæ, feet, and abdomen and occasionally in other regions of the body.

The assumption that some insects possess a true sense of hearing is based chiefly on the observed connection between their bodily structure and their power of producing sounds. It is certain that many insects which produce sounds have remarkably developed antennæ, and that others possess thin stretched membranes, which are connected with the nervous system and, therefore, appear to be analogous to the tympanum, or drum, of the human ear.

The loudly chirping stag beetle (*Cerambyx*) derives its name from its long, thick antennæ. The leaf walker (*Polyphylla*), a near relative of the cockchafer, also chirps loudly and possesses wonderfully developed antennæ which resemble great horns. The antennæ of most crickets and locusts are much longer than their bodies. Grasshoppers and migratory locusts have shorter antennæ, but the first segment of the abdomen bears, on each side, a thin stretched membrane which all entomologists describe as a tympanum. Some locusts have tympana in their feet, although they are provided with very long antennæ.

The mosquitoes and gnats (*Culicidæ*) are among the most annoying of insect musicians. As the males are vegetarians their feeding grounds are not identical with those of their bloodthirsty consorts, but the sexes unerringly find each other at certain spots where their nuptials are enlivened by music and by a remarkable and long continued aerial whirling dance performed by the males. Prof. A. M. Mayer found that the antennæ of the male mosquito, which are exceedingly long in comparison with the size of the insect, are astonishingly sensitive to certain musical notes. The sound of a C_4 tuning fork, making 512 vibrations per second, set the fibrillæ of the antennæ into especially lively vibration. C_3 and C_5, the lower and upper octaves of C_4, came next in effectiveness, while other notes produced comparatively little effect. The never-varying monotone of the female mosquito, which is so irritating to our nerves, acts as a sexual lure upon the male of her species.

It is generally known that the antennæ of insects serve, primarily, as organs of smell. The microscope, however, reveals in the antennæ sense organs of various forms. Hence we may conclude that the antennæ of some insects serve, simultaneously, as organs of several senses, including smell, hearing, and touch, and that such antennæ are larger and more complex than antennæ used for smelling alone.

Graber has found inside the bodies of insects, attached to the inner side of the shell of chitin, structures which he and other observers regard as organs of hearing. Graber calls them chordotonal organs, because they generally resemble stretched strings. As these structures have certain appendages which closely resemble parts of the organ of hearing of the locust, they appear to be really organs of hearing, but it is very remarkable that they are sometimes found imbedded in the body in such a manner that it appears impossible for aerial sound waves to reach them. Probably such organs serve only for the perception of sounds which are powerful enough to affect the whole body, as the rolling of thunder, the rumbling of heavy wagons, and the trampling of horses are felt by our bodies. Some mammals are almost deaf to sounds conducted through the air. It is said that the Greenland whale, though sensitive to the slightest disturbance in the water, cannot hear a man shouting at a distance of 50 or 60 paces.

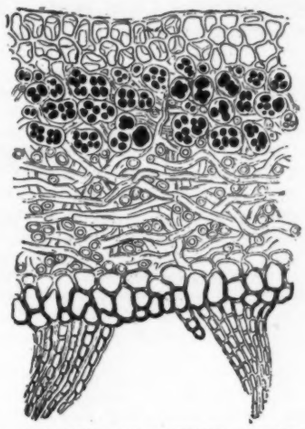


FIG. 7.—SECTION OF LICHEN, MAGNIFIED.

Fungi form the top and bottom layers and the connecting filaments; the dark round objects are algæ.

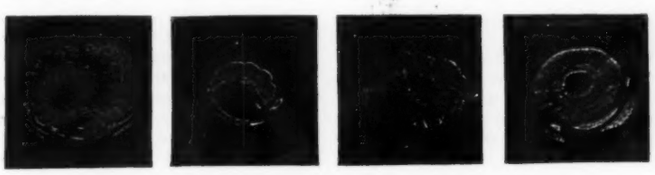


FIG. 8.—YEAST CULTURES. (¾ NATURAL SIZE.)

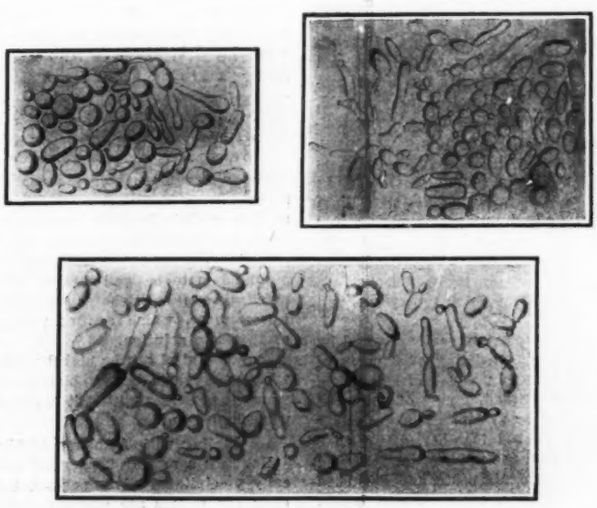


FIG. 9.—THREE VARIETIES OF YEAST. (MAGNIFIED 800 TIMES.)

The structure of the chordotonal organs of insects indicates that they were originally muscles and have been converted into organs of hearing in the process of evolution. At first they perceived only those sound vibrations which came to them through the body, but at a later stage they became associated with superficial organs (membranes, membranous canals, tympana) which could receive and transmit aerial sound waves.

In general, the hearing of insects is inferior to that of the higher vertebrates. It would be rash, however, to assume that an insect is absolutely deaf merely

because experiments have failed to detect in it any sense of hearing. Many insects hear sound of a certain pitch and quality, but are deaf to all other sounds.

Erroneous conclusions may be reached if this peculiarity were not taken into account. For example, Sir John Lubbock produced a great variety of loud tones and noises near honey bees without producing any apparent effect on the insects. It is probable that the bees did not hear the sounds, yet every beekeeper has learned by experience that bees possess some sense of hearing. When the young queens appear they emit a peculiar, fairly loud sound, which may be represented by the syllable "tuh." The old queen hears this sound, becomes violently excited, and replies repeatedly. The "voice" of the queen also produces an obvious and powerful effect on the workers. It appears, therefore, that bees can hear the sounds which they make, although they are deaf to all other sounds. It is equally possible that insects produce and hear sounds to which human beings are deaf.—Prometheus.

SILVER PLATING.

THE VARIOUS METHODS NOW IN USE.

As a precious metal possessing beauty, and yet not very expensive, silver is used to a great extent in plating other metals, to which it imparts not only its fine color, but also great resistance to outward influences.

There are a number of methods of silver plating, which may be distinguished: 1. Cold plating by rubbing. 2. Wet plating by means of boiling. 3. Mechanical plating by pressing or rolling. 4. Fire-silvering. 5. Contact plating. 6. Electro plating. The latter method is the one which at present is almost exclusively employed.

Cold Plating.—If certain silver compounds are brought into contact with other metals, such as zinc, iron, or copper, they will be decomposed, with separation of metallic silver; and this is the basis of a method of plating which consists merely in rubbing on a composition with a cork. Such a coating, however, is not very durable, and only suitable for objects which are not to be submitted to any hard wear, such as the scales of thermometers and barometers. One of the older formulas for cold plating gives the following mixture:

Silver chloride	3 parts
Salt	3 parts
Washed chalk	2 parts
Potash	6 parts

This compound is applied to the metal with a piece of moistened leather or with a cork. The object must previously be made bright, and is to be finally polished, after rinsing.

The silver chloride is obtained by dissolving silver in nitric acid, and adding to the solution hydrochloric acid, as long as there is any heavy white precipitate, resembling flakes of freshly precipitated cheese. This precipitate is filtered off, washed with water until the water, tried with ammonia, is no longer colored blue, and then dried in a dark place and also kept in the dark. Silver chloride is decomposed by light, becoming purple and finally black.

A fine even plating is produced by application of a paste consisting of 1 part of silver nitrate and 3 of potassium cyanide. This is to be rubbed on with a woolen rag, the object afterward washed, and rubbed bright with leather. It is best to wear gloves when doing this, as potassium cyanide is so very poisonous that if the smallest scratch on the hand is touched by it, dangerous or even fatal ulcers may be caused.

Silver nitrate, also termed lunar caustic or lapis infernalis, is so cheap that individual preparation of it is only worth while when it is to be used on a large scale. It can be made by dissolving pure silver in nitric acid, evaporating the solution to dryness, and carefully melting the salt residue. If the silver contains copper, it is also to be dissolved in the acid, evaporated and dried and melted, but the melting temperature must be kept up until a sample of the mass, taken out with a glass rod and dissolved in water, is no longer colored blue by addition of ammonia. In the heat, the copper nitrate is sooner dissolved than the silver salt, and the final product is pure silver nitrate, colored gray by the copper oxide mixed with it. If it is desired to have the silver compound perfectly pure, the molten mass is to be dissolved in water, the solution filtered, evaporated to dryness, and the pure salt is melted.

Small objects, such as buttons, are easily silvered by rubbing with a composition consisting of 3 parts of silver chloride, 8 parts of tartar, and 1 of salt, made into a paste. In another method, 1 part of powdered silver, chemically prepared by precipitation of a silver solution with copper, is rubbed together, dry, with 2 parts of tartar and 2 of salt, the mixture is moistened with enough water to make a thin paste, and is rubbed on with the finger or with a compact, stiff brush. Bronze, copper, or brass objects will take, in this way, a very beautiful dull white silver coating.

Cold Wet Plating.—There are upon the market various fluids, called "silvering fluid," "eau argentine," etc., which impart to clean and bright metal objects, simply immersed in them, a brilliant but very thin silver coating. Some formulas will be here given for these fluids:

Silver carbonate	1 part
Sodium hyposulphite	10 parts
Water	10 parts

The silver carbonate is obtained by pouring a soda solution into a solution of silver nitrate, the resulting precipitate to be washed and dried. Or it need not be dried, but simply put into a glass vessel with the crystals of sodium hyposulphite, where water is poured over it and the solution hastened by frequent stirring. The fluid is then poured off from the undissolved residue of the silver carbonate. The objects immersed in it are to be touched with a zinc rod.

Kayser's Plating Fluid (Argentine).

Silver nitrate	5.5 parts
Sodium hyposulphite	10 parts
Ammonium chloride	6 parts
Washed chalk	10 parts
Water	100 parts

Plating Fluid for Brass.

Silver nitrate	29 grammes (29 parts)
Potassium cyanide	120 grammes (120 parts)
Washed chalk	30 grammes (30 parts)
Water	1 liter (1000 parts)

Schirtitz Argentine Water.

Silver nitrate	11 parts.
Potassium cyanide	60 parts.
Water	750 parts.
Washed chalk	11 parts.

For use, 1 part of the compound (which should be kept in a dark colored glass receptacle) is to be mixed with 2 parts of soft water, and the objects laid in the fluid; large objects may be rubbed with a sponge or rag wet in it, rubbed, after silvering, with washed chalk and polished with soft leather.

Kurth's Plating Fluid.

Silver nitrate	2 parts.
Ammonium chloride	1 part.
Sodium hyposulphite	4 parts.
Washed chalk	4 parts.
Water	40 parts.

This fluid is suitable for copper, brass, bronze, or German silver.

Plating Fluid for Zinc.

Silver nitrate	10 parts.
Potassium cyanide	25 parts.
Washed chalk	100 parts.
Tartar	10 parts.
Mercury	1 part.
Water	100 parts.

This compound, like all which contain potassium cyanide, must be freshly prepared for use, thoroughly shaken, and applied with a brush. The silvering will take place quickly, and the object is to be afterward washed and brushed.

Böttger's Plating Fluid for Brass, Copper, Iron, and Steel.

Silver hyposulphite	2 parts.
Ammonium chloride	1 part.
Water	20 parts.

The silver hyposulphite is obtained by dissolving silver nitrate in water, adding ammonia until the resulting precipitate again dissolves, then adding a concentrated solution of sodium hyposulphite and also alcohol. The silver hyposulphite which will be precipitated is to be well washed and dried. The fluid must always be freshly prepared, since the silver hyposulphite, which can be preserved dry, soon decomposes in solution.

Iron and steel can be plated with this fluid directly, without previous copper plating, and one advantage which it possesses is that it is free from the poisonous potassium cyanide.

Plating with Amalgam of Silver and Tin.

Put into a mortar 2 parts of mercury, 1 of chemically precipitated silver powder, 1 of tinfoil, and rub until the metals are amalgamated, then mix with 6 parts of bone ash, and apply the compound with a moist rag to brass or copper; it can also be used for bronze, and gives a silvery coating, which is much finer and more durable than many kinds of wet plating.

Imitation of Cold Silver Plating.

Rub together equal quantities of mercury, tin, and bismuth, until amalgamated, and add one and a half times as much washed chalk. This compound, applied to brass, gives a silvery coating, lustrous, but not very durable.

Plating by Boiling.

Plating can be done by boiling with liquids whose composition is similar to those employed in cold plating. If, for instance, the objects to be silvered are put into a compound consisting of 6 parts of tartar, 6 of salt, and 1 of silver chloride, there will be obtained, after fifteen or twenty minutes' boiling, a beautiful and durable silver plating, which, however, is not very lustrous. If a brilliant luster is desired, the objects may be heated, on coming from the plating fluid, in a solution consisting of 3 parts of sodium hyposulphite in 32 of water, and 1 of sugar of lead in 16 of water. Black lead sulphide will be precipitated, and after ten or fifteen minutes' heating the objects will have a bright coating of silver. The heating temperature should be from 70 deg. to 80 deg. C.

Contact Silver Plating by Boiling.

The process of the so-called contact plating is similar in its nature to that of electro-plating; the copper, brass, bronze, or German-silver articles are touched with a zinc rod, by which means the more rapid precipitation of silver from one of the previously mentioned plating fluids is effected, and a heavy, durable silver coating obtained.

All the alloys above mentioned contain copper, and when this metal is brought into contact with zinc, a strong electric current is generated, which has a decided effect upon the precipitation of the silver. If zinc or tin objects are to be plated, they must, of course, in order to produce the electric current, be touched with a metal which is, in relation to zinc or tin, positive; for instance, with a copper rod.

To prevent the greater part of the silver from being deposited upon the metallic rod which is employed for the purpose of generating the electric current, it is advisable to cover the latter with a coating of good varnish, and to leave only the point bare and bright; a small blunt point will suffice for the contact.

Mechanical Plating.

Before the process of electro-plating had been so far developed that any metallic object could be covered with silver to the desired thickness, and before the so-called German-silver alloys had come into general use, mechanical plating, or plating by rolling, was much employed, and this not only gave the appearance of silver, but the plating was very durable, and much cheaper than pure silver. It usually had a foundation of copper; the process was discovered in 1722, in England, by Thomas Bolsower, and first employed in Sheffield; later, on a large scale, in Vienna, in 1755.

Silver can also be applied by this process to brass or German silver; in the latter case a product is obtained which is far superior to pure silver in point of strength and durability. The process is to a certain extent purely mechanical, and has great similarity to that by which two red-hot pieces of metal are welded together into one. A heavy plate of copper, whose surface has first been made perfectly bright, is placed between sheets of silver of certain thickness, and the three plates, heated, are carried through rollers, whereby they are made to adhere perfectly to each other. The plates are repeatedly stretched by rolling, and very thin sheets are finally obtained, which, however, in a cross section, are plainly seen to consist of three layers, the two surface layers of silver, thin, but perfectly even, and between them the copper.

Objects plated in this way are very strong and durable, since the silver coating, which becomes very dense by the repeated rollings, must be actually rubbed off before the copper can appear. If an alloy which has a similar color to silver is used as the foundation, the difference in color will not be apparent even when the objects are much worn, and they can also be replated at trifling expense by the galvanic process.

Silver-Plating of Copper.

In the plating of copper with silver, for which purpose the method above described is most frequently employed, only the finest copper is used. The copper plates, of perfectly parallel surfaces, are prepared by rolling, and rolled to a thickness of 9 or 10 millimeters, then cut into pieces about 10 kilogrammes in weight. These plates are scraped and rasped until perfectly bright, but rough, and inclosed in plates of fine silver, which have also been scraped until the surface is metallic, but rough, and which must be large enough

to extend a little way outside of the copper plates. To facilitate the adherence of the silver to the copper, it is advisable to coat these over with a thin layer of silver by immersion in some silver solution. To insure close contact between the metals, the three plates are bound firmly together with wire, and placed for a time in a concentrated borax solution, from which they are then taken, and heated at once, without drying. They may be heated by laying them upon red-hot charcoal, and covering with charcoal, and leaving until red hot, or—which is perhaps better, as preventing oxidation—they may be placed in a vessel of fireproof clay, which is heated in a furnace.

To obtain an intimate union of the two metals, the red-hot plates are beaten, starting from one edge, with a flat-faced hammer, descending at short intervals, and afterward pressed with the polishing steel, or carried through heavy rollers.

The rolling, interrupted by frequent reheating, is continued until the plates have reached the required thickness. The heating is necessary, in order to give sufficient ductility. The thickness of the plating is the standard for the quality of the product. For fine silverware, it is usually one-tenth of the weight of the copper, for lighter sheets one-twelfth, and for very light plates, such as are used for making buttons, harness mountings, etc., one-twentieth.

In plating brass, the plates are usually first tinned, and the silver applied as above; an actual melting of the silver on to the brass, which is said to be done in some factories, is probably never really done. Plated brass is little used, chiefly for ornaments, harness mountings, and buttons, rarely for coffee and tea pots.

Plating of Wire.

Silver-plated copper wire, called imitation silver wire, or Lyonese (Lyonnaise?) wire, from Lyons, one of the principal places where it is manufactured, is much used in making silver lace, but at present, however, is largely superseded by electro-plated wire. This wire is made in different ways, depending upon the quality to be produced. For fine wire, a red-hot tube of sheet silver, whose seams are simply pressed together by the polishing tool, is pushed over a perfectly bright copper cylinder, which is heated red hot, and the polishing iron used to press the silver firmly against it, after which the silvered rod is drawn out to the desired size by means of the wire-drawing implements.

For light plating, it is sufficient to cover the copper rod with several layers of leaf silver. The rod, whose surface should be rough, is heated red hot, the leaf silver applied and pressed on with the polishing iron, the rod passed a few times through the wire-drawing plate, then coated with wax, silvered again, and again drawn through the plate. For very thin plating, six layers of silver leaf are enough; for heavier, as many as thirty, applied three or four at a time.

By repeated drawings the wire will become brittle, and must often be heated again, so as not to break in drawing. Very thin wire is heated, not in coils, but wound upon a copper spool, which is heated from the inside.

If the wire is not quite heavily plated, it will soon lose its good appearance, and the process as here described is at present somewhat out of date, having been superseded, as before remarked, by electro-plating, which is much better, inasmuch as it is here possible to determine the amount of silver to be deposited, even to a milligramme, and thus to produce a silver layer of exactly the desired thickness.

Contact Silver Plating.

The so-called contact plating is a method which has a certain similarity to electro-plating; the only real difference is that in electro-plating a galvanic battery is employed, while in the contact method the electric element is produced by bringing another metal into contact with the object to be plated.

The most suitable plating fluids for use in the contact method are those which contain silver cyanide dissolved in potassium cyanide, but those which we have described above as practicable for cold plating can also be employed.

The object, made bright, is immersed in one of the plating fluids, and brought into contact, if of copper, bronze, or brass, with a bright piece of zinc; if of zinc, then with a piece of copper. In this way a galvanic element is generated, which gives an electric current of sufficient strength to decompose the silver solution. In the case of small articles, the plating is not only more quickly done than without contact, but the silver layer is heavier.

For plating small articles of brass, bronze, or zinc, the contact method is to be recommended on account of the ease with which it can be carried out; but for large objects, electro-plating is decidedly preferable. Contact plating is an excellent method for replating articles where the silver coating has been rubbed off. The spots are brushed with the fluid obtained by adding to a solution of silver nitrate enough potassium cyanide solution to dissolve the precipitate which will at first result, and fine fresh zinc filings are applied and rubbed in with a brush. By repeating this process, the silver layer can be made heavier, and the silver which has adhered to the zinc filings can be separated as silver chloride by dissolving the zinc in hydrochloric acid.—Translated from F. Hartmann's "Das Verzinnen, Verzinken, etc., der Metalle."

SCALE FOR BAROMETERS.

By C. D. CHENEY.

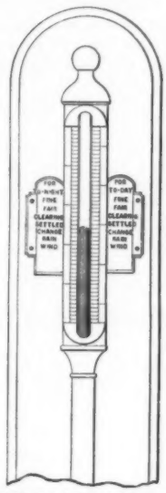
A RECENT contribution, describing the making of a barometer by an amateur, suggests the following description of a very convenient "scale" for the benefit of the ordinary observer, which the writer has had in use for a number of years with great satisfaction.

The indications of the barometer being dependent on the relative movements of the mercurial column, the scales here described are intended to afford a simple means for the necessary comparative observations.

Referring to the diagram, it will be seen there are the usual scales on both sides of the tube divided into inches and tenths; outside these are movable pieces—indices—arranged to be moved up or down, and be held where placed by a flat spring behind each. Across the center of the indices is a line lettered "Settled," and other lettering as shown, which is, however, entirely arbitrary. One of these indices is labeled "For To-day," and the other "For To-night."

In use the day index is set with the "settled" line even with the top of the mercurial column at 9 o'clock in the evening; the night index being set in the same way at 9 o'clock in the morning each day. The reading of either index holds good until the time arrives for setting the other index, and then remains an indication of the general barometric tendency for that preceding twelve hours.

These indices, used as described, take the barometer



A CONVENIENT SCALE FOR BAROMETERS.

somewhat out of the scientific class, and place it on a plane where it may become of everyday popular interest and utility.

It is known that rising barometer generally means improved weather conditions, while falling barometer indicates the opposite; but the direction of the wind should be considered in connection with the barometric indications; as changing barometer with a given wind may indicate simply an approaching change of temperature, while with a different wind the change would be of a general character. The changes which follow a rapid rise or fall of column, though likely to be very marked, are not usually very lasting.

Daily observations of a barometer and the general weather conditions will be found most interesting and instructive when assisted by these handy "indices."

SCIENCE INTERPRETED BY CHILDREN.

THE present tendency of teachers is to substitute lectures for text-books. This is an excellent method for older pupils but it is open to objection in the case of young children whose attention is easily distracted.

The child who asserted that "the hottest climate is found under the creator" and attempted to describe the "elementary canal" would probably have used the right words "equator" and "alimentary" if he could have corrected his erroneous auditory impressions by referring to text-books.

The boy who said that "the blood is putrefied in the lungs" must have been either unusually ignorant or as inattentive during recitation as he was when hearing the lecture.

Sometimes the error is caused by insufficient explanation of the teacher, as in the following reply to a question: "Usually air has no weight, but when it is placed in a barometer it is found to weigh about one kilogramme per square centimeter."

The familiar axiom that two things equal to a third are equal to each other was transformed by another child into the following astonishing statement: "If two things are equal to each other they are equal to all other things."

It may happen that the teacher, in order to explain the lesson, cites an example or an illustration which so greatly interests the pupil that he forgets the principal topic. For instance, a child who had heard the story of Newton and the apple asserted in recitation that "gravitation is especially perceptible in autumn, when the apples fall from the trees."

In order to illustrate the expansion of liquids by heat, a teacher said: "If you fill a boiler with water, close every orifice, and put the boiler on the fire, the water will expand and the boiler will burst." A young pupil rendered the illustration thus: "If you put a boiler full of water on the fire it will jump off, because the great force produced in it tries to escape." The pupil did not understand that the boiler would explode; he thought it would leap bodily in obedience to the mysterious force imprisoned in it.

[The French verb *sauter* means both to leap and to explode.—Tr.]

Another child asked to explain the difference between air and water, answered: "Air can be made more moist but water cannot." Which, at least, has the merit of truth.

The following is from a composition on the elements: "Air is the most necessary of the elements. If there were no such thing as air I should not be writing this composition and we should have no pneumatic tires, which would be a sad loss."

Here is an example of logical reasoning carried too far: "Mushrooms always grow in wet places, so they are shaped like umbrellas."

The evolution of the following is an enigma: "The probable cause of earthquakes is bad drainage and neglect of the sewers."

Steamboats and sailing vessels are thus distinguished: "A steamboat cuts the water and throws it aside, but a sailing vessel rises and falls with the waves." This error might naturally be made by a child who had seen only large steamers and small sailboats.

Electricity seems to have been confounded with electric lamps in the mind of the pupil who wrote: "Electricity and lightning are of the same nature, the only difference being that lightning is often several kilometers long, while the length of electricity is a few centimeters."

It is very interesting to follow the workings of a youthful brain in trying to explain something that has been imperfectly apprehended or understood. The teacher's task is sometimes a thankless one, but it is his duty to make sure that he is understood. He should never pass on to a new subject until the preceding one has been clearly explained and perfectly grasped.

The oral method is an excellent one but the use of text-books should be combined with it. If this is done the eye can correct the mistakes of the ear. If the child has listened inattentively and failed to catch an unfamiliar word, it is quite possible that he may read that word so attentively that he will never forget it.—Cosmos.

SAPONIFICATION WITH AMMONIA.

IN a new process for the production of soap, glycerine and pure fatty acids, the natural fats are decomposed or saponified with ammonia. The fats and the ammonia are heated for about eight hours, at a pressure of five atmospheres, in a closed horizontal iron boiler which contains a stirring apparatus and a coil of steam pipe. The products of the reaction, while still hot, are drawn off into a vertical cylindrical boiler, provided with stirrers, where they are boiled in a current of steam. The ammonia which is thus driven off is collected with little loss in a condenser for future use. The liquid is allowed to stand for a time and the fatty acids, which rise to the top, can be separated by decantation. It has been found that the solid fatty acids (stearic, palmitic, etc.) are first set free, so that they can be separated from the oleic acid by stopping the boiling at the proper point. The liquid from which all the fatty acids have been removed contains all the glycerine, which can be readily extracted by concentration.

Potash or soda soap is obtained by the same process by adding to the fats and ammonia the proper quantity of potassium or sodium chloride.

More than 17,000,000 pounds of metallic aluminium were consumed in the United States during last year, according to W. C. Phalen, of the United States Geological Survey. This is an increase of over 2,000,000 pounds over the consumption in 1906, which amounted to 14,910,000 pounds. The great increase in domestic use predicted in the early part of 1907 was not realized, and the failure of the predictions is attributed by Mr. Phalen, in large part at least, to the falling off in demand toward the close of the year as a result of general business depression.

WAVE MOTION VISUALLY PRESENTED.

PROJECTION DEMONSTRATION TO ACCOMPANY LECTURES ON WAVE MOTION.

BY WILL C. BAKER, SCHOOL OF MINING, QUEEN'S UNIVERSITY, KINGSTON, ONT.

As THE curvature method of dealing with wave transformation has secured a place in many of our best elementary text-books on physics, it may be well to point out that all the more important of these phenomena may be easily demonstrated to classes of any size by a simple projection method. The arrangements herein described enable the changes in the curvature of waves to be observed by projecting "shadows" of actual waves onto a screen. The method has been used by the writer since 1898 and has been the subject of notes in the Physical Review (March, 1900) and in the Physikalische Zeitschrift (December 22nd, 1900). It is thought well, now, to describe it in its latest form with the changes that experience has suggested.

The apparatus consists, first, of a shallow water-tight box (12 inches by 20 inches) with wooden sides and a plane glass bottom—a bit of thick plate glass preferred—and, second, of a few simple accessories such as straight bars of lead, bent strips of galvanized iron, and some simple "forms" cut from window glass. In use the box is supported over a bare arc, with the positive carbon below, so placed as to throw the shadow of the box onto the screen. It is best to have the screen inclined as in Fig. 1, but either a vertical or horizontal one (e. g., the ceiling) may be used. In the absence of an arc the projections may be made with a coal oil lamp and mirror (see Fig. 2). The first operation is to adjust the box so that its bottom shall be accurately level—any marked departure from the horizontal produces a non-uniform propagation of the waves. Water is now poured into the box to a depth of six or seven millimeters and as soon as it has settled down to comparative rest, the projection through the liquid shows a uniformly bright area on the screen. If now a wave of any form be set up, the refraction of the light from the arc in passing through the water throws "shadows" on the screen corresponding to the wave front. For instance, if the water surface be touched with the finger or with a pencil point, a circular wave is set up which is seen on the screen as a circular shadow of uniformly increasing radius advancing to the sides of the box. These waves travel quite slowly and any changes in their forms are easily followed. If a straight bar, say a piece of lath, be set edgewise into the water or removed from it, an approximately straight wave front advances at right angles to it in both directions.

FIG. 1.

In the writer's box is a device for starting a train of straight waves. This consists merely of a straight bar nearly as wide as the trough, held parallel to the shorter edge by S-shaped springs, as shown in Fig. 3. From the middle of the bar a wire passes upward and on this is a movable mass and set-screw adjusted at such a height as to give the system a period of two or three vibrations per second. A slight touch will cause a vibration that sends a train of equidistant parallel straight waves across the screen. It is necessary to caution users against any large vibration in this case as a violent disturbance is so complicated as to present no visible relation to a straight wave. When not in use for trains of waves it is advisable to block the wire into a fixed position with a piece of wood between it and the box edge. This is to prevent it vibrating with accidental touches.

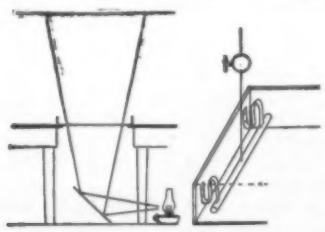


FIG. 2. FIG. 3.

* School Science and Mathematics.

The first demonstration in the usual course, is to show that the waves in their progression do not carry the medium forward with them. To do this a region of water is colored by introducing from a dropper about a tenth of a cubic centimeter of ink. On causing a train of waves to pass over the inky portion the class can see that the colored water is not carried onward by the waves. The same remark applies to small chips floating on the water surface.

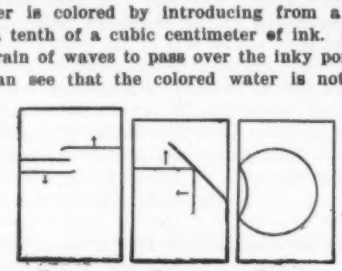


FIG. 4. FIG. 5. FIG 6.

Next one usually calls attention to the spherical waves obtained in a homogeneous medium and illustrates the remarks with circular waves on the screen. In most cases it is best to use single waves and not trains of waves as it is easier to concentrate the attention of an audience on the transformation of a single wave at a time. Attention is now directed to plane waves as parts of spherical ones of large radius and one or two straight waves are sent across the screen. It is well to use these last two points as introductory, for it secures that the class, having seen the meaning of the moving shadows in these simple cases, will the more readily interpret them in more complicated cases.

In dealing with the phenomena of reflection, it is found best to begin with a case of normal incidence, as follows: A leaden bar is placed partly across the field as in Fig. 4 and a single plane wave is sent against it. Both the undisturbed and the reflected parts of the wave are clearly visible traveling in opposite directions with equal speeds. (See Fig. 4, where the arrows give the direction of motion of the wave fronts.) When the reflector is set at an angle (best at 45 deg.) the change in the wave front appears as in Fig. 5. Reflection of circular waves is shown against the side of the trough (see Fig. 6) and ideas regarding the image are introduced. Reflection from curved surfaces is demonstrated by employing strips of galvanized iron bent to the required shape. A single plane wave sent into a concave arc is seen after the reflection as a circular wave converging to the focus and then diverging therefrom. A circular wave set up at the focus may be observed to leave the reflector as a plane wave. Both the curved and straight parts are clearly visible (see Fig. 7). Conjugate foci of course follow in the same way, also images in concave reflectors. Reflectors of different curvature may be produced either by further bending the strip of metal used above, or by employing different strips. Reversing the strip so as to present the convex side to the waves enables one to show the phenomena of convex reflectors. The dissipation of energy at reflection may be shown by simply starting a circular wave and watching it die out after successive reflections at the sides of the trough.

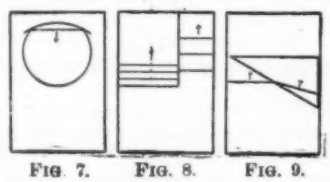


FIG. 7. FIG. 8. FIG. 9.

All these phenomena are strikingly distinct if attention is given to having the trough quite level, as any tilt causes differences of depth with corresponding variations in the speed of the waves.

The velocity of a wave is of course dependent on the depth of the water, so we can easily show refraction effects by producing shoal places in the tank. This is best done by cutting window glass to the forms required and mounting these on three or four legs cemented with sealing wax. If small strips of glass be cut, say 1 centimeter by 5 millimeters, two or three of these mounted one on top of another makes a good leg that raises the upper surface of the glass "form" 5 or 6 millimeters above the bottom of the box. To make the sealing wax hold, it is of course necessary to gently heat the glass (in an oven) until the wax will melt on its surface. While it is still warm it is well to smear the wax all around the lower edge of the form so as to leave a strip about 5 millimeters wide that will throw a shadow on the screen. This is necessary in order that the class may see distinctly just where the shoal begins. The glass shoals must be quite clean so that they will wet easily with a shallow layer of water, and the water surface must be adjusted so that it is about 1 millimeter deep over the upper surface of the shoal. A broad camel's hair brush is most convenient for spreading the water over the shoal, as capillarity generally prevents it flowing over by its own force.

It is best here also to commence with normal incidence. A single plane wave is sent onto a rectangular shoal (see Fig. 8) and the retarded and unretarded portions of the wave are visible at the same time. The idea of the index as being the ratio of the velocities in the two media should be now introduced. If a train of waves be sent onto the shoal the shortening of the wave length is easily seen. Refraction at other incidences is shown by triangular shoals as in Figs. 9 and 10; the first being the refraction in passing into a region of smaller propagation velocity, and the latter the converse. In the second case there is no change of direction in passing onto the shoal as the incidence is normal, and attention may be centered on the change in leaving this region. Refraction of circular waves in both of these cases is given as in Figs. 11 and 12, where the disturbance is started by simply touching the water surface with the finger over the deeper part, and over the shoal respectively. The changes in curvature are evident.

The case of the double bending by a prism is shown as in Fig. 13 where the lines *a b c* represent short leaden stops to prevent diffraction effects from obscuring the phenomenon. Under good conditions one may even show total reflection at the base of the prism. Principal and conjugate foci of lenses are shown with lenticular shoals as in Fig. 14 used with stops at the corners as in the case of the prism.

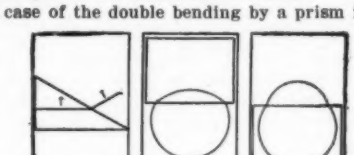


FIG. 10. FIG. 11. FIG. 12.

The analysis of a wave into component wavelets may be suggested as follows: Two barriers of lead are set across the trough leaving only a small opening near the middle Fig. 15. A plane wave sent against this is reflected except at the gap, where a circular wavelet proceeds into the space beyond. If two or more gaps be left, one sees a series of these partial waves, and if one use nine or ten, say a centimeter apart, they may be seen to build up again into an approximately plane wave. It is easier though to make a "comb" by driving a dozen inch nails one centimeter apart into the edge of a piece of lath, so that the heads lie in a straight line. If this be dipped into the water, a dozen circular waves are set up, which, in proceeding across the screen, build up into a very good plane wave. This is particularly instructive as both the elementary and resulting waves are clearly seen.

A simple case of diffraction is obtained by sending the waves against a barrier that extends two-thirds of the way across the trough. A plane wave sent against this shows diffraction at the edges after passing the bar (see Fig. 4).

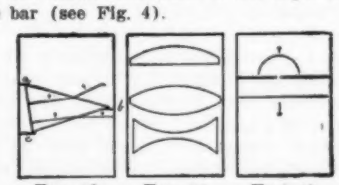


FIG. 13. FIG. 14. FIG. 15.

The great beauty of the phenomena referred to delights all classes, and the simplicity with which these results may be attained must appeal to all teachers of the subject. The whole secret of success lies in having the apparatus level, the surfaces clean, and the water not too deep over the shoals. These conditions being secured, one must use only single waves (wherever possible) to have complete success.

In conclusion I wish to acknowledge my indebtedness to my brother, H. S. Baker, B. Sc., for suggesting the spring vibrator and for certain other details in the development of the method.

A WRITING CAM.

A NOVEL PIECE OF MECHANISM.

BY A. E. SCHULZ.

ONE of the manifold uses to which cam motion may be applied is illustrated in the accompanying engraving of an arrangement called a writing cam. It consists of two cams of such outlines that a complete turn will make the pencil at the end of the upper follower *A* trace the letters U, W, make the short dashes in place of periods behind each letter, and return to the starting point. A closer inspection shows that while the upper follower carrying the pencil makes up and down movements, the lower one *B*, by means of a spring which keeps it in contact with the lower cam face, advances the paper at the proper rate in accordance with the movements of the pencil.

In designing the cams, the first step is to construct the chart shown in the lower right corner. For this purpose the letters or words are carefully drawn out and framed up as shown in the smaller rectangle, which is then divided into a sufficiently large number of equal parts, which are denoted by the letters of the alphabet, reading from right to left. To get the chart proper, a larger rectangle is drawn of any convenient length. The lower part of this figure is of the same height as the letters and contains the curves of the upper cam *C*, while the height from the base to the top line is equal to the length of the smaller rectangle, as can be seen by the letters on the vertical line, and contains the curves for the lower cam.

The base line is next divided into an even number of equal parts, a multiple of four being preferable, because these lines represent as many radii and the base circle has to be divided into the same number of parts. In the present case 96 divisions were chosen, as this permits of convenient subdivision. Having completed this step, the next is to evenly distribute or virtually stretch the letters over the lower part of the figure, leaving enough room for the home stroke, and then referring to the letters at the end of the rectangle, find the curve for the lower cam *D*. For instance, referring to the chart, while the pencil forms the straight line of the U which extends over radius 1-6, the paper does not move, therefore, that part of the curve for the lower cam is a horizontal straight line. The curved part of the same letter covers radius 6-14, and as the motion is uniform, the other curve drops uniformly to the intersection of radius 14 and a line drawn from between *ON*. The curve then stays at this height for the other straight part of the U to radius 20, then drops from *N* to *M* and radius 22, for the break between the two letters. In forming the W, the curve drops successively from *M* 22, to *J* 34, to *G* 46, to *D* 58, to *A* 70, each of these drops corresponding to one straight part of the letter W.

If the uniform law of motion had been followed, the curves would have been straight lines for the straight parts of the letters. In the present case this would, however, result in sharp corners at the joints of the W, which again would result into abrupt changes in the cam outline. To avoid this, the harmonic law of motion has been used, which insures continuous and smooth curves and cam outlines. The lines from 70 to 96 are for the return stroke, and being of minor importance no special law of motion has been employed.

To lay out the cams, the base circle and the large circle which passes through the fulcrum of the upper lever follower, are drawn and divided into the same number of equal parts as the chart. In numbering these radii, care must be taken in locating the zero point for each cam, which lies at the respective point of contact of cam and follower. Going out from the base circle, the distances of the chart are stepped off on the corresponding radii. As, however, the upper

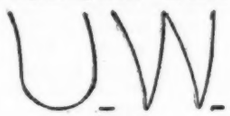


FIG. 2.

The letters as they would appear, owing to the circular movement of the pencil, if the cam controlling the movement of the paper were not corrected to prevent it.

follower moves in circular arcs, it is evident that the distances must be laid off on arcs drawn from the various division points of the fulcrum circle with a radius equal to the lengths of the follower from fulcrum to point of contact. Connecting then the various points so found by a continuous line, the theoretical cam curve is obtained. If roller followers are used, the working curve is found by the usual process of reducing the contour an amount equal to the radius of the roller. In this case this applies to the upper cam only.

The working curve of the lower cam is identical with the theoretical, except for a correction due to the circular movement of the pencil, which would give the letters a distorted appearance, as shown in Fig. 2. It is therefore evident that, if a straight line is to be drawn, the paper must be moved back and forth just enough to take up the arc formed by the pencil. The way to find the proper distance to be added is shown at *E*, where *a-b* is the height of the letters and arc *a-d-b* the path of the pencil. The divisions are the numbers of the radii over which the part of the letter extends. The chart shows that each stroke of the U covers 10 radii, from 0 to 10 and 10 to 20, while the W requires 12 for each stroke, from 22 to 34, from 34 to 46, from 46 to 58, and from 58 to 70. Two constructions are therefore necessary. Adding now the distance between line *a-b* and arc *a-d-b* to the corresponding radius to the previously found curve, the rectified working outline of the cam is obtained.

To produce the break between the letters, a little metal strip at the bottom of the upper cam presses the upper follower down at the proper moment and thus lifts the pencil off the paper. The same principle is applied for the return stroke. As soon as the last part of the W is formed, at radius 70, as the chart shows, the pencil is lifted and goes to the bottom line from radius 70 to 75. At radius 75 the metal strip is interrupted and the pencil drops down and forms the dash behind the W from radius 75 to 76, where the lower cam dwells from 76 to 77 to give the pencil time to rise and thus insure a sharp line to the finish. The same process is repeated for the dash behind the U, where the dwell extends from 88 to 89.

As a suggestion, it might be said that it is advantageous to use a fairly large construction and also to avoid letters where straight lines appear, as far as possible, as this would facilitate the work considerably by permitting the use of uniform motion curves throughout and thus doing away with the correction mentioned before. This correction might also be avoided by the introduction of some mechanical device for converting the arc formed by the pencil into a straight line, as for instance Watt's straight line motion, or other contrivances.

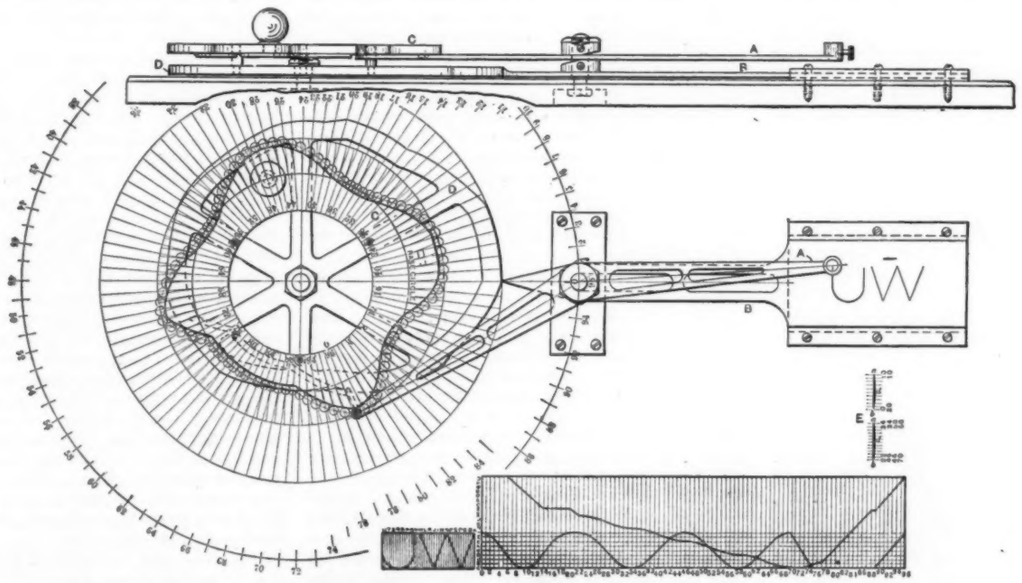


FIG. 1.—METHOD OF LAYING OUT THE CURVES FOR THE TWO CAMS WHICH CONTROL THE MOVEMENTS OF THE PENCIL AND PAPER.

* Machinery.

RECENT PROGRESS IN THE MANUFACTURE OF VARIOUS GASES.

GREAT progress has been made within recent years in the production of various gases.

The chemical processes of producing oxygen are rapidly being abandoned. The most important of the new methods are the electrolysis of a dilute solution of soda with electrodes of iron, and the fractional distillation of liquid air (Claude's patent). The electrolytic method has already given rise to a very flourishing industry, but the liquid air process, though interesting in theory, has not yet reached the stage of practical efficiency.

The production of ozone has been characterized by the invention of many new types of apparatus. The difficulty is to produce air containing a large percentage of ozone.

Chlorine is produced in large quantities in the electrolysis of salt in the manufacture of soda. Indeed, the production of soda in this way is limited by the difficulty of disposing of the chlorine. A great deal of the chlorine is now used in making carbon tetrachloride. A metallurgical application of chlorine is also suggested, in the form of a process of separating metals by the difference in volatility of their chlorides.

The carbon dioxide which is sold in the liquid form comes almost entirely from coke furnaces and lime kilns. Recently this gas has also been obtained from mineral springs, some of which evolve it in vast quantities. The springs of Loudra in Turkey yield

35,000 cubic feet at a pressure of 10 atmospheres, and the springs of Herst in Westphalia yield 70,000 cubic feet, at 20 atmospheres, every hour.

Sulphureted hydrogen obtained by the action of acids on sulphides has been utilized in Transylvania for the production of sulphur, by reaction with sulphurous acid in presence of moisture.

In the ammonia industry a noteworthy innovation is the Kaiser process, in which a current of nitrogen brought into contact with heated calcium or magnesium hydride, produces the corresponding nitride and ammonia. In another stage of the process the nitride is reconverted into hydride, and more ammonia is generated by the action of a current of hydrogen. Commercial ammonia is also produced by the action of water vapor on calcium cyanide.

Nitrogen, which had no industrial use a few years ago, has acquired commercial value since the synthesis of nitrogenous compounds has been proved practicable. It can be produced easily by the fractional distillation of liquid air.

STUTTERING AND STAMMERING.

THE PSYCHOLOGY OF SPEECH.

ORDINARILY, we make no difference between stuttering and stammering. Strictly speaking, however, as J. P. Filskow explains in an instructive article in a recent number of the Illustrirte Zeitung, stuttering is merely an inability to join the syllables and words into fluent and rapid speech; whereas the term stammering he would apply to cases where, while the speech is fluent, some of the letters cannot be correctly sounded. The cause of stuttering, he goes on to say, is now known to be a derangement or impediment in the brain, whereby the nerves that set in action speech-producing muscles are not under full control. As to its cure, parents should employ every means to strengthen and make healthy the nerves of school children with a tendency to stutter; careful nourishment of the body, invigoration by means of water, air, and sun baths, as well as by all sorts of gymnastic exercises, games, and exercise in the open air, etc. The clothing must not compress the respiratory or neck muscles. Everything that produces psychic disturbances (intimidations, terror, anxiety, fear, and the like) should be avoided. The declamation of long pieces at school by young children is to be discouraged as often tending to develop stuttering. When children wish to tell their parents of an exciting happening, they should be made to quiet down first, take several deep breaths, and then relate very slowly and without stops. After progress has been made in stuttering, the shame children may feel at their malady hinders their making effective effort to overcome it. The feeling should be combated with affectionate treatment and cheerful intercourse devoid of all compulsion; the stutterer must never be blamed, nor on any account mimicked; but quietly and at great length it should be explained to him that, by means of certain exercises and the observance of fixed rules, he may become cured of his infirmity and speak exactly as well as anyone else.

When the stutterer has been brought so far as to acquire self-confidence, then we may proceed to the cure of the disease. This consists of a series of exercises, by means of which he is to obtain complete mastery over his nerves and muscles of speech, so that no longer shall any muscular convulsion occur in his vocal organs. In the first place, the unnecessary concomitant motions (nodding, shrugging the shoulders, stamping, etc.) made merely with a view to removing the hindrance to fluency, must be suppressed. These take place involuntarily and unconsciously. Let the stutterer now be taught to keep them up for some time voluntarily and consciously, at a low word of command. In this way we will learn to subject to his will the muscles involved, so that in future he will be able to suppress the disturbing motions.

Then let all sorts of exercises for the development of the chest and respiratory muscles be undertaken. Useful here are exercises with the arm (lifting, whirling, rolling, stretching, striking, pushing) and with rods. Of great value are breathing exercises. Whereas in a sound person, when he speaks the respiration is scarcely noticeable, this takes place in the stutterer spasmodically, noisily, and with great effort. He either inhales too little air, or hinders the current to be exhaled by a convulsive compression of the larynx. Usually, too, he does not use the air economically, at once exhaling it when it has scarcely been inhaled. The stutterer should therefore be accustomed slowly and deeply to inhale the air, equably in one breath, through the nose, and without pause to exhale it again in the same manner. Then let him be shown how economical breathing is done. He should be made to inhale deeply, then make a pause of retention, and next inhale and exhale intermittently.

With this are connected exercises for the strengthening and voluntary development of the voice and the articulation muscles. Generally, stutterers place the tip of the tongue convulsively against the lower incisor teeth; thereby a strong pressure is brought to bear as well upon the root of the tongue as upon the larynx, and the glottis is to a certain extent compressed. In order to overcome this, let the stutterer open his mouth quite wide, while at the same time placing the tongue in a straight and loose position at the bottom of the cavity of the mouth. Now let him perform through the open mouth the same breathing exercises as before through the nose. In so doing let him breathe at first lightly, then harder, and let him join each of the vowels in turn to the breathing tone. From the strengthened breathing tone let him gradually proceed to whispering. A very commendable exercise, which throughout is easily performed by all stutterers, consists in speaking and reading in a whisper. The beginning should be with words that have predominantly a vowel sound. Finally, the normal speaking tone must be introduced. In doing this, the speaking or reading should not be too strenuous or loud; at the same time, it should be insisted upon that it be done syllabically, and, above all, the vowels, at least at the beginning, should be drawled. In this way the stutterer should be accustomed gradually with good emphasis to speak connectedly. In all the exercises, attention is to be paid to an erect military carriage (chin high, shoulders back, chest out) and to the observance of the breathing rules. If in so doing the stutterer speaks always slowly, at first low and rather drawlingly, he will finally learn to speak with tolerable certainty and correctness.

The writer has the following to say about the cure of stammering:

As appears from the preceding explanations, it is difficult for the laity to treat stutterers correctly. Much more thankful is the task in case of stammering (so called), because here the cure is easily effected, and no relapses follow. The stammerer forms some sounds (consonants) incorrectly and speaks unhandsomely. The cause may lie in a faulty structure of the cavity of the mouth, the lip or the roof being cleft (hare-lip and malformation of the palate). This causes organic stammering, which can be cured only by the surgeon's aid. As stammering also is reckoned speaking in a disagreeable nasal tone. This imperfection of speech is often caused by the soft palate with the uvula being relaxed, so that the latter, instead of resting against the back wall of the throat, hangs down loose. This evil readily disappears, when the nasal speaker talks continuously in a very high and loud voice; that is to say, the stronger current of air causes a contraction of the soft palate, which consequently rises with the uvula and closes the entrances to the nasal cavity. This method may be used, especially with such persons as on account of excessive saliva or too large tonsils speak indistinctly and unhandsomely.

One of the most frequent impediments of speech is lisping, i. e., the imperfect enunciation of the sibilants, particularly of the consonant *s*. These are correctly sounded by closing both rows of front teeth, slightly furrowing the tongue ,and placing its tip lightly at the middle of the lower incisors. The lisper cannot do this. He thrusts his tongue in the formation of the *s* sounds between the tolerably wide open rows of teeth, so that it is always in his way, and he must inevitably stumble over it.

In order to correct this fault, let a slender stick such as a toothpick, be laid diagonally across the front part of the tongue, so that it bears on the two lower canine teeth. Now have the lisper make the *s* sound and speak continuously. In this way he is obliged to keep the tongue in the correct position. Another method consists in demanding of him in speaking or reading to press the teeth hard together; thus, too, the tongue will be perforce kept back. Finally, the lisper in speaking or reading should always keep the tip of his tongue down to the gums of the lower incisors. Let him practise awhile in slow speaking or reading according to these rules; his fault will then soon disappear. There are also lispers who place the tip of the tongue at the gum of the upper incisors, when they utter a sibilant sound. In this case likewise, let the toothpick be applied. Others, again, draw the tip of the tongue back; with them the top of the tongue arches, and a sound similar to *sh* is made. In such a case, let the toothpick be placed lengthwise upon the tongue, and so pressed down that the stick lies directly upon the center of the lower incisor, and the current of air is involuntarily directed there.

Another impediment of speech also often found is *l* stammering. Its victims substitute the *n* sound for *l*; for example, *naugh*, *fnat*, *bnue*, instead of *laugh*, *flat*, *blue*. Both sounds are formed, to wit, at the same place by placing the tip of the tongue at the gum of the upper incisors, with the difference that in the *n* sound the side edges of the tongue are pressed against the front and canine teeth. In this way the current of air can not get out of the mouth, but is forced to escape through the nose, thus producing the nasal sound. If now a child assumes this incorrect position in making the *l* sound, we should open its mouth very wide, and at the same time close its nose tightly. Thereby the formation of the *n* sound is made difficult, and it pronounces *l*, though at first not a very well-formed *l*. Should this treatment fail, a toothpick should be thrust from either side into the region of the upper canines over the edges of the tongue and be pressed down, and the child itself should close its nose. The current of air must now find the proper exit, and involuntarily the *l* is sounded.

Children frequently use *t* for *k* and *d* instead of *g*; e. g., *tome* and *tind* instead of *come* and *kind*, *do* and *dood* instead of *go* and *good*. This kind of stammering comes from their pressing the tip of the tongue upon the gum of the upper incisors, and then suddenly projecting the current of air thus hindered. For correcting the fault let the following treatment be tried: By the aid of a slender penholder, the handle of a teaspoon, or a flat stick, the tip of the tongue should be pressed down firmly, and the stammerer should now be required to sound *t* or *d*; *k* or *g* is then pronounced without trouble.

In conclusion, it should be pointed out that most impediments of speech are not inborn but acquired. What the children hear, what is spoken before them, they imitate. Hence all parents should take care that their children should hear correct speaking.

A NOTEWORTHY ANTHROPOLOGICAL DISCOVERY.

A DISCOVERY which will no doubt give rise to considerable discussion has recently been made in France, and it is of great importance as concerns the question of the origin of the human race. Two members of the clergy, the Abbés Bouyssoni and Bardon, have been engaged in making prehistoric excavations near the locality of Chapelle-aux-Saints in the Correze region, and during this work they found human remains which consist of a skull, this being intact although slightly broken, and also the upper and lower members of a human being, but this individual shows characteristics which present marked differences from the present human race. At the same time it is differentiated from the monkey race, so that we appear to have here an intermediate species. At a recent meeting of the Académie des Sciences, M. Perrier, the distinguished scientist and present director of the Natural History Museum, commonly known as the Jardin des Plantes, presented the question before that body, and he is of the opinion that we have here the vestiges of what is certainly the most ancient human being yet discovered. The remains in question were discovered in the Middle Pleistocene earth, which represents the epoch near the end of the Tertiary period and at the beginning of our Quaternary epoch. Beside the remains which were discovered here were found several rhinoceros teeth, and this points to the fact that the individual lived in a period when the climate which prevailed in France was almost tropical. The animals which lived during this period were the long-haired mammoth, the rhinoceros, certain species of deer, etc. Naturally the skull of the individual was the first point to be examined, and fortunately it is in a fair state of preservation. It was given a very careful examination by M. Perrier, and gave conclusive proof of certain facts as regards the point where we are to place the specimen. It is observed that the jaw is very much lengthened, and the jaw-bones do not possess any canine teeth. The nose is very wide and it is separated from the frontal bone by a considerable depression. This gives a muzzle-like character to the face which is clearly observed. On this account, therefore, the above characteristics bring it to a near approach to the simian type, but on the other hand the skull cavity is much larger in size and volume. Thus we find that by some of its char-

acteristics the specimen has the features of a human skull, but the individual is also of a lower order and comes near the physiognomy and organization of the monkey.

As to the members which were found with the skull, they appear to be of a curved shape in general, and they show a special conformation which allows of deducing with certainty that the individual remained more generally in a crouching position or with the four members on the ground, than in a standing position. It seems thus to assume the positions which lie between those which are assumed by the human being and the monkey. M. Perrier concludes that the present specimen should be assigned an intermediate position between the specimen known as the *pithecanthropus* and the ordinary human being. It is to be remarked that this specimen is much more ancient than the portion of skull which was found at Neanderthal in Germany near 1867 or the remains discovered at Spy, Belgium, somewhat later. The remains have been acquired by the Museum, where they will be made the object of further researches. We expect to recur to this subject in a more complete description.

WEEDS THAT ARE USED IN MEDICINE.

SOME SIMPLE BOTANICAL FACTS.

BY EMMETT C. HALL.

SINCE the earliest days of agriculture, weeds have been regarded by the farmer as his greatest pest, and he has waged a futile war of extermination. A shower that scarcely serves to even temporarily revive a wilting crop will bring up weeds by the million; and anyone who has had experience will testify that the average weed is possessed of a vigor and singleness of purpose—to grow—almost satanic.

Since centuries of agriculture have produced no genius to bring forward a method of eradicating them, the next best thing is to make some use of them. Many weeds which are very common throughout large sections of the United States have considerable commercial value, and as they have to be removed anyway, the farmer might as well realize something on them. The labor of preparing weeds which have a value as crude drugs is not hard, and in most cases may be done by women or children. Many a farmer's boy might add considerably to his income by collecting marketable weeds in his spare time.

Because the weeds are everywhere, in the fence corners and along the roadside, it must not be thought that carelessness is permissible in gathering them or in thoroughly drying them, whether they be roots, herbs, barks, flowers, or seeds. If not thoroughly dried, they will mold, and the collector will find his labor wasted, as he cannot dispose of his stock. Another point of great importance is to see that the drugs collected are free from any foreign substance; that is, they must be clean in every way, with no fragments of other plants or barks mixed with them. A good, fresh color adds to the market value, and this can be retained by drying the crude drugs in the shade, instead of exposing them to the direct rays of the sun. Above all things, the collector should be sure that he is gathering the right plant or root. There are many weeds which closely resemble each other, one of which may be extremely poisonous. If in any doubt as to the identity of the weed or bark he is about to gather, he should send a specimen to his state experiment station, or take it to some competent chemist or botanist.

In collecting roots, it must be remembered that during the growing season they are deficient in medicinal properties, and that they also shrink more in drying, and consequently weigh less, than when gathered at maturity. The roots of annual plants should be dug just before the flowering period, and those of biennials or perennials after the tops have dried, the former in the autumn of the first year, and the latter in the fall of the second or third year. All roots should be washed clean of dirt. After washing, the roots should be dried from three to six weeks; clean, well-ventilated barn floors or lofts are the best places to spread them. If they are dried out of doors, they should be protected at night and from rain. Large roots should be split or sliced, in order that they may dry more quickly.

Bark of trees should be gathered in the spring, when the sap is beginning to flow, and dried as are roots, except that bark may be exposed to the sun. Only the inner bark of the elm, hemlock, poplar, oak, pine, and wild cherry is of value, and the coarse outer bark must be shaved off before the inner is to be obtained. Leaves and herbs should be collected when the plants are in full flower, and as it is very desirable that they retain their bright green color, they should be dried in the shade. In collecting leaves of the smaller plants, the entire weed may be cut and the coarser stems afterward thrown out. In the case of herbs, only the flowering tops and more tender stems and leaves should be broken off. Shriveled and discolored specimens should never be allowed to remain with the good product. Both leaves and herbs require some stirring and turning to dry thoroughly. Moisture will cause them to darken. Flowers should be gathered when they are just opening, or soon after, not when full blown or beginning to fade, and they should be dried in the shade as are the leaves. Seeds should be collected just when they are ripening.

To dispose of the lot of crude drugs after they have been prepared for the market, a good sample—three or four ounces—should be sent to the nearest commission merchant or large drug house. The local druggist can furnish names and addresses. Each sample should be well wrapped and marked with its name, and the sender's name should also appear on the package. It should also be stated what quantity of each drug the sender has to dispose of, and he should, of course, inclose return postage. On account of freight charges, it is well to sell as near the point of production as possible. When ready for shipment, the crude drugs may be packed in tight bundles, wrapped in burlap or gunny sacks or in clean dry barrels. Flour barrels, by reason of their lightness, are good.

There are a very large number of plants used in medicine, but those mentioned below are the ones most commonly met with, and most salable. As with everything else, the price paid for crude drugs varies, but it is not likely that the value will fall below or rise above the figures given. As the same weed is given different names in different sections of the country, all of these names are given in each case.

Burdock (cockle button, cuckold dock, beggar's button, hardock, and bardane) is one of the most common of American weeds. It is a biennial, and attains a height of 3 to 7 feet. In the second year small clustered heads of flowers appear. These flower heads have hooked tips, which in the autumn and winter catch in the clothing, and in the wool and hair of animals. Only the root of burdock is of commercial value in the United States. This root is large, about 12 inches long, of a fleshy nature, brownish or grayish outside, and of a lighter color inside. These roots should be washed, split lengthwise, and dried as before directed. In drying they lose about 4/5 of their weight, and become wrinkled and scaly, with a weak and unpleasant odor. The value is from 2 to 8 cents per pound.

The little yellow dandelion, known also as blow-ball, dankerwort, horse gowan, Irish daisy, and one o'clock, is found all over the world. The part to be gathered for medicinal purposes is the root, which is large for the size of the plant, being sometimes 20 inches in length, dull yellowish or brownish outside and white inside. This root should be dug between July and September, washed and dried. The price per pound is 4 to 6 cents.

Of dock weeds, there are several species which may be collected; yellow dock, broad-leaved dock, and yellow-rooted water dock, all being more or less abundant throughout the United States. These weeds are too well known to require description. The root is from 6 to 12 inches long, fleshy, the outside dark reddish brown, with a rather thick bark, and yellowish inside. It has a faint odor and a bitter, astringent taste. Roots should be collected in late summer or autumn after the fruiting tops have ripened. They should be split into halves or quarters, and carefully dried. The different varieties should not be mixed. The price for dock root ranges from 2 to 8 cents per pound.

Pokeweed, known also as pigeon berry, ink berry, pocan, American nightshade, cancer jalap, and red weed, is found in rich, moist soils, along fences, margins of fields, and uncultivated land all over the eastern half of the United States. Pokeweed attains a height of from 3 to 9 feet, and in Europe it is used as an ornamental plant for gardens. Both the root and berries of pokeweed are used in medicine, and both should be collected when the berries are fully mature, usually about two months after the flowers appear. The clusters of berries should be carefully dried in the shade. These berries are poisonous, as is the root. The large, fleshy root should be cut into transverse slices before drying. Pokeroot brings from 2 to 5 cents per pound, and dry berries about 5 cents per pound.

Mullein, or Aaron's rod, Adam's flannel, blanket leaf, candlewick, old man's flannel, Jacob's staff, lady's foxglove, shepherd's club, velvet plant, etc., is a native of Europe which is rapidly gaining a firm foothold in America. Everyone is familiar with mullein, and at once recognizes the whitish woolly or felt-like leaf and tall, straight stem. The plant sometimes attains a height of 7 feet, and the leaves are from 4 to 12 inches long and without stems. During the first year of its growth there is only a rosette of soft leaves, flat upon the ground, but during the second year the tall flower stalk appears. Both leaves and flowers are collected at the period when the plant is in bloom, and the leaves are cured in the usual manner. It is desirable that the flowers retain their bright yellow color, and they must be thoroughly dried and then kept in well-corked bottles to prevent them from absorbing moisture, which they readily do. The corolla (petals) with the adhering stamens only is dried, the calyx being rejected. Dried mullein leaves may be smoked like tobacco to relieve nasal catarrh and throat affections. In Germany mullein is cultivated on account of its medical value. From 2½ to 5 cents should be received for dried leaves, while flowers should bring from 25 to 75 cents per pound.

Tansy (bitter buttons, ginger plant, parsley fern, or scented fern) is found along waysides and fences in the Eastern States. It is a strong-scented, perennial herb with a stout, erect stem from 1½ to 3 feet in height. Tansy flowers from July to September, having roundish, flat-topped yellow flowers in dense terminal clusters. The leaves and tops are collected at the time of flowering and dried in the usual manner. Tansy is decidedly poisonous. The value of the drug is from 3 to 6 cents per pound.

Boneset, also known as ague weed, feverwort, sweating plant, Indian sage, and wild sage, is a weed known almost everywhere as of value in fever and ague. Its chief characteristic is the fact that its leaves, springing from the stalk in opposite directions, are joined at the bases, giving the appearance of a single leaf with the stem thrust through the middle. Leaves and flowering tops should be collected together, and dried. The value will be from 2 to 8 cents per pound.

The flowering tops and leaves of catnip and hoarhound may also be collected and dried in the usual manner, though not a great deal of the former is demanded by the drug trade. Its value is 2 to 8 cents per pound. Hoarhound, however, is used in considerable quantities, and brings from 3 to 8 cents per pound.

The jimson weed (thorn apple, stinkweed, devil's apple, devil's trumpet, etc.) is exceedingly common throughout the country with the exception of the North and West. It is a native of the tropics, and has that appearance, growing rankly, with stout yellowish-green stems and thick, smooth, pointed leaves from 3 to 8 inches in length. The white, funnel-shaped, and rather showy flowers are produced from May to September. Jimson weed is very poisonous. Both the leaves and seed of this weed are medicinal. The most convenient way of collecting is to cut down the entire plant, and hang it up to dry, afterward stripping off the leaves. To gather the seed, the pods containing them should be collected when the seeds are quite ripe, but the pod still of a green color. After a few days of drying the pods will burst. Place the pods in a sack and beat with a stick, afterward sifting out the seed. Dried jimson weed leaves are worth from 2½ to 8 cents per pound, and the seed (stramonium is the name given them by the drug trade) from 3 to 7 cents per pound.

Soap paste may be made by combining hard soap with glycerine, water, and caustic soda. An ordinary soap vat is charged with 400 to 600 parts of dry pulverized oil or tallow soap, 400 to 600 parts of soda, 100 parts of glycerin, and 11,000 parts of water. The mixture is heated, with constant agitation, to ebullition, and is then poured into kettles and heated to from 125 and 140 deg. F. for a period varying from 12 to 24 hours. Perfumes and other ingredients may be added, as in the case of hard soaps, and the caustic soda may be replaced, wholly or in part, by caustic potash or carbonate of potash.

ENGINEERING NOTES.

The advantages of ball bearings for fans over plain white metal bearings were recently determined in a series of tests referred to in an English contemporary of a 35-inch exhaust fan so designed that it could be operated either with the plain or ball bearings. When adjusted for the same volume and conditions of delivery, it was found that slightly over 7 per cent more power was required to operate it with white metal bearings than with the ball bearings, while, when adjusted for the same power inputs in either case, an increase of delivery capacity of over 7½ per cent was secured with the ball bearings in use.

A single-leaf bascule bridge of the Strauss trunnion type was recently put in service by the Chicago and Northwestern Railway across the north branch of the Chicago River. It carries about 260 trains a day, apart from shuntings, and the river traffic is such that it must be opened about 1,000 times a month. The operating machinery is housed at the top of the tower. Power is furnished by two 50-horse-power motors. The driving pinions operate two racks connected to the first panel point ahead of the 28-inch trunnions, and a spur-gear equalizer synchronizes the movement of the two racks. There are also hand-power and pneumatic drives. The locking mechanism includes a front support for taking live load off the trunnions and a truss lock at the rest pier end. The trunnion pier was carried down 115 feet to bed rock.

In a recent issue of the Mining Journal there appeared a translation of an article by Mr. Ia. M. Pitersky in the Russian Gorny Journal, in which a novel method of regulating spouting oil wells is proposed. Briefly, Mr. Pitersky's method consists in sinking a shaft at the top of the well to a depth equal to about sixty times the diameter of the last series of pipes sunk, this shaft having a diameter of from ten to fifteen times that of the last series of pipes. Near the top of this shaft there enters a pipe connecting with the reservoir. As soon as oil is struck and the oil jet issues under the pressure of the contained gases to a great height oil is let into the shaft from the reservoir, and the height of the jet gradually decreases until when the top is reached it has been entirely absorbed, and the flow is even; the oil can then be led to the reservoir along with the gas it contains, thus avoiding the danger and losses incidental to fires.

It is remarkably difficult, states the author of an article on "Motor Engineering," to find the cause of noise in an engine, but he has obtained considerable assistance in this direction by using a stethoscope. It will be found useful for motor car purposes to increase the length of the rubber tubes to two or three times the standard length, and when this has been done it will be found quite easy to hear separately each piston moving up and down in its own cylinder, each valve tapping as it falls onto its seat, or each trembler with its distinctive buzz, according to the adjustment of its platinum contacts. When ascribing all noises to blows of one kind or another it is noteworthy that when two sliding surfaces are insufficiently lubricated they may either chatter together or, if the rate of chattering is extremely great, produce the well-known shriek which is generally the forerunner of a "seized" part; in either case the noise is probably due to rapid blows between the minute projections on the dry surfaces; in such cases, however, the higher temperature of the part affected will place the trouble without any necessity for importing a scientific instrument.

Directions for making cement pipe joints in ordinary bell and spigot pipe were given at the recent Kansas City convention of the Natural Gas Association of America by Mr. J. B. Clumpp, as follows: The joint should consist of one roll of yarn just long enough to reach once around the pipe, driven to the bottom of the bell; then cement solid to within 1½ inches of face of bell; next a second roll of yarn, and finally a facing of cement. Use Portland cement of relatively quick-setting characteristics; natural cements are not uniform in quality. Use the cement neat, and as dry as practicable, so that hammering the yarn against it is necessary in order to bring the moisture to the surface; for this merely enough water should be added to the cement to cause it to appear crumbly in mixing, and just to retain the impression of the fingers when squeezed in the hand. Use the cement immediately after mixing; if it lies unused for over 5 minutes, it should be discarded. Use jute yarn untarred; when the joint is made, the yarn and sides of the joint may be moist, but should not be wet. Care should be taken to have the surface of the bell and spigot as clean as possible, any appreciable rust being scraped off with a wire brush, or removed with gasoline, if necessary. Keep the pipe cool, and at as nearly as possible a uniform temperature until the joint is firmly covered, which may be accomplished by covering with wet burlap, and if joints are made in hot days it is advisable to cool the pipes by applications of water.

ELECTRICAL NOTES.

The Schweizerische Elektrotechnische Zeitschrift gives an account of a large battery which has recently been supplied to one of the rolling mills of the Carnegie Steel Company. There are 125 cells, capable of giving out 10,000 amperes over long and 15,000 amperes over short periods. The employment of such a battery has been necessitated by the great load variations in the mills, which are driven by two 250-volt 750-kilowatt motors. The current taken by these motors may vary by 15,000 amperes within a few seconds, thus necessitating the use of two generators. By the use of the battery, however, the employment of the second 1,000-kilowatt generator could be discontinued, and the machine used as a reserve. The working machine operates at nearly constant load, the battery taking up the "peak."

Soldered junctions in electric conductors often develop faults due to the action of the soldering liquid or to imperfect scraping of the soldered ends. These ends should be thoroughly sand-papered and tightly wrapped with 1/25-inch wire which has also been sand-papered, and rosin should be used instead of acid. Even these precautions do not insure a perfect joint. Hofmann advises the substitution of riveting for soldering. The ends of the wire are inserted into an appropriately formed socket of pure copper, in which, between the wires, two holes are made with a conical punch. When the rivets have been driven in and clinched the wires are wedged tightly between them and the socket, and a perfect joint is assured. The operation is very simple and can be performed in two minutes by unskilled workmen, while soldering requires a large expenditure of skilled labor.

The Electrical World describes a new type of electric furnace now being manufactured by the General Electric Company for operation on alternating-current circuits, metallic salts being reduced to a liquid state by means of an electric current. The furnace consists of a fire-clay crucible, surrounded by an insulating material, usually of asbestos, which rests in a fire-clay box. Two electrodes are placed on each side of the crucible, and are in direct contact with the bath at all times. When the bath has reached its proper temperature, that portion of the material to be hardened is submerged in the liquid, and is allowed to remain there until it attains the same color as the bath, when it is removed and tempered in water or oil, as the case may be. The bath for hardening or annealing consists of equal portions of barium chloride and potassium chloride. The ultimate temperature depends on the relative proportions of the two chlorides; the higher the percentage of barium chloride the higher is the temperature.

Experiments in connection with the smelting of tin ore in the electric furnace have been conducted in France recently. As a result, it was found that the chief advantage of electric smelting is the fact that the slag will absorb much less tin as silicate and will contain no metallic tin occluded in form of globules. The disadvantages of electric smelting are, first, the loss of tin as vapor and as dust, though this loss may perhaps be reduced when operating on a larger scale. The second disadvantage is the greater impurity of the tin produced. Te remove lead from tin a process similar to the Pattinson process may be employed. The tin product of the electric furnace contains about 2 or 3 per cent of lead. The tin-lead alloy is heated to the melting point—about 230 deg. C.—and then slowly cooled to a temperature a few degrees above the melting point of the eutectic—180 deg. C. This temperature is maintained for some time. Pure tin crystallizes out, while the heavier eutectic mixture of 30 per cent of lead and 70 per cent of tin remains. This may be repeated several times. By treating a 2 per cent lead alloy in two refining processes the lead is reduced to 0.2 per cent.

A hydro-electric power station, capable of producing 7,200 kilowatts, has recently been erected on the St Joseph River at Berrien Springs, Mich. The energy thus obtained is used for bulk supply, and two steam stations, with a rating of 1,500 and 3,500 horse-power are used as auxiliaries. The dam is constructed of concrete, flanked at both ends by an earthen embankment, and in the center there is a spillway, 145 feet long, to pass floating debris and ice, which are diverted to it by means of heavy timber booms. At one end of the spillway is a section containing six Tainter gates for passing flood discharge, and between the gate section and the bank on that side there is an earthen embankment 550 feet long. At the other end of the spillway is the generator house and penstock section, 261 feet long over all, the generator house being part of the water-stop. The generator house measures 64 feet by 112 feet, and is provided with accommodation for four main 1,800-kilowatt Westinghouse generators at 2,300 volts, 60 cycles, and operating at 150 revolutions per minute. Each of the four generators is driven by a set of four pairs of 45-inch Leffel wheels, which work under a normal head of 20 feet.

TRADE NOTES AND FORMULÆ.

Kordigene, a New Fuel, by Kordig.—The process of making this fuel, for use for heating or lighting, consists in mixing petroleum or tar-hydrocarbons of 0.4 to 0.75 specific gravity, with 1 to 5 per cent of acetone ether, ½ to 3 per cent of sulphuric ether, which may be dissolved in glycerine, and ½ per cent of perfumed alcohol.

Copying Paper, Blue or Black.—Take fine lampblack or ivory black, indigo carmine, or ultramarine, mix the one or the other of these coloring substances thoroughly with soft soap and rub the mass produced in this manner, with the aid of a stiff brush, on thin but strong paper, whereby a far better copying paper is produced than that made with fatty oils.

Cement for Attaching Stones to Metal. (For buckles or pins.)—In a covered vessel, 7 parts of vulcanized rubber and gutta percha and 2 parts of sulphur are melted together. For use, a small part of the mass is melted and applied to the heated surfaces. A spirit lamp suffices for the operation, but in making the joint care must be taken that there is no trace of moisture.

A Cement for Stoneware is made up of 15 parts of litharge, 10 parts of white quartz sand and 15 parts of borax. The mass is melted to a frit in a crucible and this is then poured into cold water, powdered, precipitated in water, stirred with gum water and applied to the broken surfaces. On the object being heated the cement melts.

Jegel's Preserving Fluid, for Preserving Small Animals.—The animals are laid in a solution of 125 parts of sulphate of alumina and 10 parts of crystallized carbolic acid in 1,000 parts of water, the fluid to be changed until it remains colorless. Then the animals are placed in a solution of 200 parts of sulphate of alumina in 1,000 parts of water, to which a solution of 5 parts of arsenious acid in 500 parts of potash lye of 1.11 specific gravity and 50 parts of glycerine of 1.23 specific gravity have been added.

Wood-Wool Planks and Wood-Wool Slabs.—The materials of which wood-wool planks and wood-wool slabs are made, consist of wood-wool and lime mortar, composed of two parts by volume of sand and one part by volume of burned and slaked lime. For the sand may be substituted coal ashes or coke reduced to the granular size of sand. Further materials are: plaster addition to the mortar above mentioned, an impregnating fluid, to preserve the wood-wool from decay, such as creosote, carbolineum, or anti-merulion, and finally water for the preparation of the mortar. The wood-wool, after previous drying, is placed in a vessel containing creosote or carbolineum and left in it until a thorough impregnation of the separate wood-wool fibers—threads—is effected. Taken from this bath, the wood-wool, in a wet condition, is tied together in bundles and dried. Treated in this manner, the wood-wool is protected against destructive influences, even when inclosed lightless and airless, and is insured against fungous growths. Thin, that is to say quick-fluid, lime mortar, consisting of 2 parts of sand or sandlike ground coal ashes or coke and 1 part lime, is mixed with liquid plaster, in the proportion required for slow or quick setting, and kept ready for pouring into molds. According to the form of the wood or iron, separable molds to make the planks or slabs or stones—box-shaped, with one narrow side removed—the wood-wool bundles are introduced vertically, and these wood-wool cores being properly secured, the mortar is poured into the molds. That the wood-wool core must be smaller than the mold, according to the desired thickness of the sides of the planks, slabs, and stones, is understood. In consequence of the vertical casting, the mortar, under the influence of its own gravity, penetrates into the wood-wool core and under the least favorable circumstances leaves but small, unconnected voids. These small hollow spaces occurring, do not affect the wood-wool planks, slabs, or stones, as far as affording a refuge for vermin. After the mortar has set in the form, the finished boards, slabs, or stones are removed from the molds and stored until completely hard. Experience proves that lime mortar, through a slight addition of plaster, acquires the hardness of stone and does not display the slightest hygroscopic property.

TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—The Efficiency of Aerial Propellers.—By W. H. TURNBULL.—1 illustration 235

II. BIOGRAPHY.—Practical Value of Edison's Inventions to the World.—I.—By FRANK L. DYER and T. COMMERFORD MARTIN. 230

III. BIOLOGY.—Artificial Mutations of Animals and Plants as the Basis of Technical Biology.—9 illustrations. 235

IV. ELECTRICITY.—Influence of Over-voltage on the Life of Metallic-filament Lamps. 231
Electrical Notes. 230

V. ENGINEERING.—The Rowell-Potter System of Railway Signaling.—By FRANK C. PERKINS.—5 illustrations. 229
Engineering Notes 228

VI. MINING AND METALLURGY.—Testing the Hardness of Metals.—8 illustrations. 227

VII. TECHNOLOGY.—Extraction of Potash and Soda from Minerals. 231
Safeguarding Wood against Ants. 231
Trade Notes and Formulæ. 234